WATER RESOURCES

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HEARINGS

BEFORE THE

SELECT COMMITTEE ON NATIONAL WATER RESOURCES

UNITED STATES SENATE

EIGHTY-SIXTH CONGRESS

FIRST SESSION

PURSUANT TO

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DENVER, COLO., NOVEMBER 20, 1959

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WATER RESOURCES

FRIDAY, NOVEMBER 20, 1959

U.S. SENATE,
SELECT COMMITTEE ON NATIONAL WATER RESOURCES,
Denver, Colo.

The select committee met at 9 a.m., in the senate chambers, State capitol building, Denver, Colo., pursuant to call, Hon. Robert S. Kerr (chairman of the committee) presiding.

Present: Senators Kerr, Martin, Allott, and Carroll.

Also present: Theodore M. Schad, staff director, and Paul McBride, chief clerk.

The CHAIRMAN. We are glad to be in Denver for the 14th hearing of our committee.

We are greatly interested in the portion of the testimony that is to be given us about the needs of the next 10 and 20 years for additional water supplies by the State of Colorado, its great capital city, and its other cities and communities and agricultural areas. We shall be glad to have the benefit of the suggestions of those who are most familiar with the various proposals as to how those need can best be met.

We are glad to be again in the home State of Ed Johnson, who was one of our most cherished Members in the Senate for many years, and to be here with your distinguished Senators, Allott and Carroll.

I am happy that Senator Tom Martin, of Iowa, a member of our committee, is with us and if he has anything to say we will be glad to have him say it.

Senator MARTIN. Thank you.

I look forward to this hearing with very great pleasure indeed. I have come to listen rather than to expound on the subject before us today.

We have some very interesting testimony coming forth and I will defer to them at this time, Mr. Chairman.

The CHAIRMAN. Then that passes the ball to Senator Allott, for such statement as he may care to make.

Senator ALLOTT. All right, Mr. Chairman, first of all, I would like to welcome—would you prefer that I sit up there?

The CHAIRMAN. Well, sir, you do whatever is most convenient to you, Senator.

Senator ALLOTT. At least I will stand up because I feel like I am in the well, sitting way down here.

STATEMENT OF HON. GORDON ALLOTT, A U.S. SENATOR FROM THE STATE OF COLORADO

Senator ALLOTT. I want to welcome this committee to Colorado, particularly the distinguished chairman of the committee, and my colleague in the Senate from Iowa, Senator Martin.

We are happy to have you here and I believe you will find as the day progresses that this will produce a great variety of problems and questions because the Colorado water situation is so complex by reason of our terrain, by reason of the source of the rivers, that there are very few problems in the conservation and use of water which do not arise or have not arisen in the State of Colorado.

The program which will be presented today will cover all the aspects of our water problems. I will be followed by Senator Carroll, and the Governor, and many others.

The Colorado State University, which is represented here by President William Morgan, will make a presentation including soil moisture problems, seepage control, desalinization, and evaporation prevention, all of which, of course, are specified in the enabling resolution.

The water conservation board will cover other particular uses and point out that our growth will demand unusual attention to the development of water within the State of Colorado.

Our potential needs for industrial uses, municipal uses, and agricultural uses, is very great and our growth, of course, in this State, has been so rapid that it posseses particular problems which arise, in turn, out of the very complicated situation we have here in our water uses.

Despite the distrust and sometimes breaches in the past because of the future of growth between the east and west slopes, many, many years of devoted effort by many people seem to begin to be paying off at this time, although we do have deficiencies, and probably will always have these.

Then this does not mean that Colorado is not going to devote itself completely to development of water resources in Colorado and to help solve its own problems.

I might say particularly for the benefit of our two visiting Senators, before you in the room today you have many outstanding persons who have worked with water as lawyers, as engineers, and as instructors for many years and it would be very difficult in any State of the Union, I believe, to gather together under one roof a more distinguished group of authorities upon water than you will have before you today.

Denver, of course, will be represented here and will present its own particular problems with regard to coordination of use, reuse, stream sanitation, and other things.

The University of Colorado spokesman will cover weather forecasting.

Of course, the Colorado River Basin is of very prime concern. It originates 72 percent of the water in the Colorado River and under the upper Colorado River compact is entitled to 51.75 percent of the water.

The development of this whole great basin depends primarily now upon the development of the Curecanti, Flaming Gorge, and Glen Canyon Dams, which in turn will enable us to more quickly develop the other participating projects of the upper basin.

We need to do this, we need to get the county started as an absolute necessity to get us over the hump in the development of water and to keep our water from flowing down the Colorado River to the benefit of a great State, but a State which has already compacted with us to leave it up here with us.

There will be a further discussion by the Colorado Water Conservation District upon this particular matter.

Now, the San Juan Basin which is in the southwestern corner of the State, is a part of the upper Colorado River development and its special needs and significance will be presented by the Southwestern Colorado Water Conservation District and the Arkansas River, which is, I might say, as you know, down in our joint bailiwicks, will be discussed by the southeastern district.

In this respect I might call the attention of the committee, and also particularly of all here, to the very great need for the Frying Pan-Arkansas project, which will provide some municipal water for the municipalities in southeastern Colorado and also provide a supplemental source of supply of irrigation water to the farms, some farms, in the valley.

It will not put a single extra acre of land under irrigation, but it will enable a portion, at least, of the farmers in that area to level off some of the peaks and valleys from their economic mountains by way of studying and levying out their water supply so that during the bad months of the summer, they can have supplemental supplies.

Northeastern Colorado is probably and generally the best served, but also they will be here to testify not only about the operations of the Big Thompson, the South Platte, but also the problems of the growth of population, which has just literally exploded in the last 10 years in this area, bringing problems of water pollution and other matters.

I would like to say just one other thing. I am sure that the chairman and members of the committee are aware of the basic principles of Federal water rights which have been expounded particularly by the Attorney General and, I hope that we will also have some comments on this today, particularly with respect to the bill or the several bills which are now pending in the U.S. Senate to reassert in the States the water rights, which we feel should be controlled, owned, and governed completely by the State practices.

I would just like to ask that the chairman include the remarks I recently made before the National Reclamation Association on this particular matter, and I would like to ask that these remarks, together with a table attached to them, may be made a part of the record.

The CHAIRMAN. Very well.

(The material referred to follows:)

REMARKS OF SENATOR GORDON ALLOTT BEFORE NATIONAL RECLAMATION ASSOCIATION

I am proud to have been invited to address the National Reclamation Association and it is a pleasure to welcome and be with you here at your 28th annual meeting.

All of us in Colorado, particularly those of us interested in water problems, know of the great work of the National Reclamation Association. We are honored that you have chosen Denver for your meeting.

It is entirely appropriate that the association meet here in the capital of Colorado, where many of the great western rivers originate. It is perfectly natural, but we are nonetheless extremely proud of the fact that many of the great western leaders also originated here. Colorado is particularly proud of our State director for NRA, who is also your vice president and host at this convention, the very distinguished and competent Harold Christy.

Incidentally, if it is all the same with everyone, we would prefer to share more of our leaders with you and less of our water.

But, fortunately, you are not here to consider the allocation of any of the great rivers, but the development of all of them. There is great need for your continuing assistance in that development.

The population of this country is now about 175 million. In 20 years it is reliably predicted that there will be about 275 million of us, and in a mere 40 years, we may well have doubled our present population.

My good friend, and Secretary of Interior, Fred Seaton, has predicted that a population of 350 million people will require the availability of approximately 600 billion gallons of water a day—nearly 3 times as much as the present consumption of 240 billion gallons of water daily.

Such need will require wise planning and imaginative programs in the field of water conservation. The saline water program, now well underway, may be of great assistance in that regard. Effective control of evaporation in reservoirs will be important, as will the elimination of water waste to phreatophytes—water living plants. In all these efforts, I am sure this association will be in the forefront of the fight to provide adequate water supplies to communities and farmers, as they have in the past.

One important phase of the struggle for adequate water development will be the development of realistic and honest solutions to the complex question of Federal-State relations in the water field.

Most of you here will remember well the broad congressional review of the States water rights in connection with Senator Barrett's bills, S. 863, in the 84th and the 85th Congresses. I was pleased to be a member of the Senate Interior Committee during those investigations and am familiar with the complex and difficult issues raised.

There are now before the Congress three different types of bills, all of them intended to be responsive to resolutions of this association, and all designed to clarify the rights of the States to control the use of waters within their borders. The objectives of all these bills, and of this association, is to clarify and redefine the meaning of Federal constitutional and statutory provisions.

There are two principal issues presently in contention and these are:

(1) Shall the agencies of the Federal Government have the right to use waters arising on or flowing through Federal reservations in opposition to laws of States prescribing uses, priorities of appropriation, administration of water resources, and the planning of future developments?

The Supreme Court has, in effect, so declared, according to the Department of Justice. And

(2) Shall Congress define by a specific statute what is meant in the several Federal authorizations for navigation, flood control, and power projects, by the references to improving the channels of commerce between the States and foreign powers?

Namely, what do we want the navigation servitude to mean with respect to our water supplies?

The Supreme Court has, in effect, held that all waters in our land, tributary within the drainage basin to a navigable stream, are waters subject to the dominant jurisdiction of the Federal Government.

However, Federal agencies designated to carry out these authorizations are created by the Congress, and, in this particular reference, they are controlled by laws passed by Congress under its constitutional power to regulate commerce.

It seems to me that attorneys representing some Federal agencies are saying:

"The United States has constitutional powers over navigable waters; also, that by virtue of owning lands, particularly lands in Federal reservations, the Federal Government thereby has these lands vested with unique and unlimited riparian rights; and whether proceeding under the commerce clause or the property clause of the Constitution, it is not subject to the laws of any State where navigable waters are consumed or where reservations are found."

The assertion that I have mentioned would seem to be based on an assumption that the Constitution itself, by a hop-skip-and-jump feat never before equalled in the field of law, gave jurisdiction over the streams of the country to the executive branch, subject only to review by Federal courts. The error here in such an assumption is that the legislative branch of our Government is ignored.

Constitutional powers could not be exercised in connection with our water development and flood control projects without the authority expressed in acts of Congress.

In section 8 of article 1, the so-called Commerce Clause reads as follows:

"The Congress shall have power * * * to regulate commerce with foreign nations, and among the several States, and with the Indian tribes."

Now this does not say that a Federal agency may operate under the Commerce Clause of the Constitution absent the authority of Congress.

We are faced with a report submitted to the Senate in the 85th Congress on S. 863, the bill then before the Senate Interior and Insular Affairs Committee.

This report, while transmitted by Secretary Seaton, Department of the Interior, stated that it was concurred in by the Departments of Justice, Defense, Interior, Agriculture, and the Bureau of the Budget.

Included with the report was the draft of a recommended substitute for S. 863 which we were assured would be approved by the President. This substitute has generally been referred to as the "agency bill" and is the basis for S. 851, sponsored by Senator O'Mahoney, Senator Bible, myself and others.

We are also faced with the fact that there have been several instances where the House of Representatives has refused to consider minor amendments to omnibus flood control bills that would require of the Secretary of Army compliance with the laws of the States respecting the development of water resources under flood control programs.

S. 863 had two objectives: to clarify the scope of the navigation servitude and to confirm congressional intent regarding the ownership of waters arising on a Federal reservation.

I should like very much to accomplish both objectives.

For the immediate future, however, to seek both may mean the realization of neither.

It would be foolish on our part not to go ahead and put to rest the "reservation doctrine" while we have everyone agreed to it. I foresee no great difficulty in gaining enactment of S. 851. Then we could proceed with the long, difficult task of clarifying the obligations and rights of Federal agencies under State law, generally.

Our first and most important obligation is, therefore, to deal with the clouds on many western water rights which derives from the "reservation doctrine."

I believe that the many excellent attorneys identified with your association and its member States and irrigation districts will agree with me that there is immediate necessity for legislation along the lines of S. 851.

Let us, therefore, consider the Federal reservation theory as applied in granting licenses to build hydroelectric plants on reserved lands free from restrictions in the laws, rules, and regulations, of any State or States within which a project may be situated.

The Pelton Dam decision resulting from *Federal Power Commission* v. *Oregon* (349 U.S. 435), held that the jurisdiction of the Government, through the Federal Power Commission, was founded upon the ownership or control by the United States of the reserved lands on which the Pelton project was located. And, the Supreme Court further held:

"There thus remains no question as to the constitutional and statutory authority of the Federal Power Commission to grant a valid license for a power project on reserved lands of the United States, provided that, as required by the (Federal Power) Act, the use of the water does not conflict with the vested right of others. To allow Oregon to veto such use, by requiring the State's additional permission, would result in the very duplication of regulatory control precluded by the first Iowa decision (328 U.S. 152, 177–179). No such duplication is called for by the Federal Power Act."

The point, I think, is that Congress expected the Federal Power Commission, under the safeguards of the act, to require of any licensee that he conform to the laws of an involved State.

This was an enabling law designed to put to work falling water obtained by building dams on streams in instances where financial feasibility was demonstrated, where no interference with other beneficial proposals or plans could possibly result.

This was implied in section 9. This is the real issue.

If this decision is permitted to stand, all unappropriated water, as of the date of the license issued, could be assumed to be appropriated by the licensee if his power generating facilities required those flows, regulated or unrelated by storage by decision of the Federal Power Commission.

If any unappropriated waters remained after satisfying the requirements of a licensee, who would make such determination?

There are established ways to secure water rights in the Western States. The rules are simple. The result is a complete record of water rights in each State, all rights being subject to administration by the authorities in each State.

Would a Federal Power Commission licensee be answerable for infringements or interferences with the users who have rights under State laws? The answer is that the situation presents a dismal future following an orderly past.

Let us now consider the effects of the Federal reservation theory of water controls and uses. I have prepared a table which gives areas in Federal reservations in the reclamation states, which I hope may be shown in the record of this meeting.

It shows four classes of reservations: National forests, Taylor Grazing Act lands, Indian reservations, and Defense Department reservations.

Omitting from the 17 reclamation States, Texas, Nebraska, and Kansas, which have only insignificant reservations, 42 percent of the areas of 14 States are in some category of Federal reservations. Of this, 16 percent is in forests, 18 percent in grazing lands, 6 percent administered by the Bureau of Indian Affairs, and 2 percent is under military controls.

The average area of the 14 states is 100,000 square miles.

These figures now begin to have meaning.

Thus this imaginary average State would have 16,000 square miles in national forests, 18,000 square miles in grazing lands, 6,000 square miles administered by the Bureau of Indian Affairs, and 2,000 square miles under military controls.

The national forests, while aggregating only 225,000 square miles in these 14 States, yield all but a small fraction of the flows of perennial streams, which streams constitute our dependable supplies for irrigation, supplies for our cities and towns, and for our industries.

If waters originating on a Federal reservation are excluded from the jurisdiction of States, then the States may not administer water rights; nor may they plan for more comprehensive developments; nor may they and their appropriators, under their laws, question, limit, or define power developments authorized by the Government on their streams.

This result is, in my judgment, unthinkable.

These considerations led to the introduction of S. 851.

The enactment of this type of legislation would probably not prevent another Pelton Dam license, but the licensee would not have a right to store, regulate, or use water as against an appropriator under State law unless he followed the established procedures under the laws of the States involved. So, while a license might be granted, the licensee would never construct the project until the State concerned issued him a permit. And such permit would not in any way be dependent on a Federal license.

Time does not here allow me to detail the 100-year history of congressional consideration of western water problems, but I believe Bill Welsh has earlier distributed to the membership a careful review of that history prepared by Elmer Nelson of the Senate Interior Committee staff and made a part of the House Interior Committee hearings this year by Senator O'Mahoney. That shows the 30 Federal statutes, spanning the period from 1886 to 1958, which require recognition of State laws as governing water rights. They are evidences of a consistent congressional record unmatched in any field of statutory law. The West, particularly, has relied on these principles established by these laws, but the Department of Justice says they are meaningless.

Of our 50 States, 20 are not public land States for the reason they were not created out of the public domain, namely, public lands under national domination.

S.851, the "Agency bill", does not affect these 20 States which include the 13 Original Colonies, and the States of Maine, Vermont, West Virginia, Kentucky, Tennessee, Texas, and Hawaii.

S.851 deals with reservations of public lands, and reservations within the public land States. There are Federal reservations in the public land States easterly of the hundredth meridian. They are not extensive, and I have not made an analysis of this data. For example, Florida has 2,000 square miles and Michigan 4,000 square miles in such reservations. Thus it can be seen that we are not alone in the West. There are other States which share our present concern.

The second issue mentioned earlier concerns Federal controls over the Nation's fresh water streams where they are navigable, or where they contribute to downstream reaches of rivers that are used or are usable for interstate commerce.

I shall discuss this issue briefly.

It was claimed by witnesses representing the Department of Justice at hearings on the Barrett bill and on the bills before the House Interior Committee this year that the Desert Land Act of 1877 did not cede to the States and the Territories rights to control or grant appropriations to the use of waters from navigable streams.

As we all know, the Supreme Court's definition of navigable waters in the case of *Oklahoma* v. *Atkinson Co.* (313 U.S. 525), when applied literally, includes nearly all western streams and other natural bodies of water. Our right to control our waters is thus in danger from another premise, namely, that navigable waters are solely within the domain of Federal control. This was evidenced in the decision in *First Iowa Hydro-Electric Cooperative* v. *Federal Power Commission* (329 U.S. 152 (1946)). This decision rested on the thesis that:

Navigable waters are subject to Federal uses under the commerce clause of the Constitution. The Department of Justice attorneys say that navigable waters are not subject to appropriation under State laws and procedures. They rely, I think, entirely on the phrase "and not navigable" appearing in the third unnumbered clause of section 1 of the Desert Land Act of 1877. The analysis of this section, however, discloses the fallacy of their posotion. The act by its terms authorizes and does not prohibit acquisition of the right to use water.

The clause in question clearly refers to two different classes of water:

(A) "surplus water over and above such actual appropriation and use (by a desert land entryman)," and

(B) "other sources of water supply upon the public lands and not navigable."

Under this construction the approval of the appropriation and use of surplus water is not limited to nonnavigable waters, but includes navigable waters as well.

We know that the Desert Land Act is specific in authorizing a method for the disposal of that portion of the public domain, not otherwise disposed of, which was at the time believed to largely comprise the Great American Desert. This name held only a little while because 10 million acres in 55,000 entries diverted both navigable and nonnavigable waters, without distinction, to irrigate these desert lands. Entrymen had their rights to use water from States or agencies of States, and these rights were adjudicated in local courts.

The Government, acting through its General Land Offices, issued patents after examining the sources of supply, evidence of water rights under State laws, and the application of water to the irrigation of the lands of the entrymen.

Does anyone now contend seriously that navigable waters in the so-called arid West have not been appropriated under local laws?

We are now faced with court decisions, administrative regulations of Federal Agencies, and the further situation that silence by the Congress appears to give recognition and consent to the extension of Federal controls. This trend is entirely unnecessary in connection with either navigation or flood control improvements by the Government.

We must inquire, what waters were considered by Congress to be navigable prior to enactment of the Federal Power Act of 1920, and what should now be done by Congress to redefine navigable waters.

I do not feel that there is anything holy about the language of S.851, and do not believe that Senator O'Mahoney or Senator Bible, or any of the other sponsors do either. A number of amendments were submitted at the House hearings on these bills this year.

Those, and any others subsequently submitted, or recommended by this association will be carefully considered, I know, by all of us on the Interior Committees of the Senate and House, before a bill is reported.

One thing we must do before this congress adjourns is to lay to rest, permanently, the reservation doctrine as advanced by some of the Government's attorneys and, apparently adopted by the Supreme Court in the *Pelton* case. Having eliminated this cloud on our water rights we can then set about developing a reasonable solution to the controversy that has arisen over the scope of Federal rights and powers based on the navigation clause.

In both efforts I know we can count on the continuing, enlightened and effective support of the National Reclamation Association.

Thank you.

17 Western States—Land in Federal reservations

[Areas in square miles]

State	Area of State	Areas in Federal reservations					Percent [1]
		Forests	Grazing	Restricted and Indian	Defense Department	Total	
Arizona	113,956	17,800	19,700	30,300	4,900	72,700	64
California	158,297	31,200	25,600	900	6,200	63,900	40
Colorado	103,948	22,400	12,350	1,170	300	36,200	35
Idaho	83,888	31,800	17,800	1,320	1,400	52,300	62
Montana	146,997	29,000	10,340	9,130		48,400	33
Nevada	110,690	7,900	72,200	1,800	6,000	87,900	79
Oregon	96,669	23,300	20,500	2,670	200	46,700	48
Utah	84,990	12,350	38,240	3,800	3,600	58,000	68
Wyoming	97,914	14,300	25,100	2,960	100	42,500	43
Washington	69,127	15,150		4,200	600	19,900	29
New Mexico	122,503	14,400	21,280	10,100	2,000	47,800	39
North Dakota	70,837	1,700		1,430		3,100	4
Oklahoma	70,027	400		3,030	100	3,500	5
South Dakota	77,615	3,000		8,740	500	12,200	16
Kansas	82,158	180			200		
Nebraska	77,520	530			150		
Texas	265,896	1,200			700		
Totals	1,407,488	224,700	263,100	81,500	25,700	595,000	42
Percent	100	16	18	6	2		

[1] Reservations total in percent of State total.

NOTE.—Totals exclude the 3 States, Nebraska, Kansas, and Texas, as areas in reservations are not significant.

Senator ALLOTT. In conclusion, I would like to say, Mr. Chairman, that we welcome you here. I do not want to try to take the time to discuss particular phases of this which all of these people from the various parts of the State can discuss more fully, more ably, than I can.

But I do want to welcome the committee and thank you very much for taking this extra time to come into our State and to listen to our problems, which I am sure you agree cover every facet of water development, that the mind can conceive.

Thank you very much.

The CHAIRMAN. Thank you very much, Senator Allott.

I want to say for the record that the chairman and the committee were and are of the opinion that no series of hearings would be complete without having given full opportunity to the people of Colorado to be heard. Since it seemed to be more appropriate and more convenient for that to be done in Denver, we were happy to accept your invitation from your two Senators, delivered to us by Senator Carroll, to come here. We are happy to be here with you, and John, we are happy to be here with you.

Now, we will be glad to hear from you, such statement as you care to make and such witnesses as you care to present.

STATEMENT OF HON. JOHN CARROLL, A U.S. SENATOR FROM THE STATE OF COLORADO

Senator CARROLL. Mr. Chairman and Senator Martin, members of the staff of this very excellent committee, I first of all want to join with Senator Allott's welcome and second his analysis of the witnesses that will be called before this important hearing.

Through the cooperation of Senator Allott and Governor McNichols and Mr. Larry Sparks, who is one of our top water experts and Director of the Colorado Water Conservation Board, we have sought to bring together the witnesses in this State who will touch upon almost every phase of its water problems.

I do not mean, necessarily, that they will come forward with solutions, but they will come forward with their problems.

Of course, implicit in this study of our national water resources is the problem confronting all water projects in the future, namely, how we are going to finance them under existing law, unless we can change some of that law in view of the rise in the interest rates and the resulting financial problems that lie ahead.

This is very important not only to Colorado, but to the whole West.

From time to time throughout the hearings today, if I may be permitted, I would like to interrupt and put questions. If that is agreeable and in view of the excellent introductory and greeting statement of Senator Allott, there seems to be no need for further comment from me at this time except to thank you again most sincerely in behalf of the people of Colorado for coming here.

I hope the public will understand that this is a tremendously important committee. It was back in 1952 that President Truman's Materials Policy Commission issued its report on the resources requirements of this country through 1975. This report estimated our national water needs by 1975.

But if you heard Senator Kerr's speech last night, you would know that no group operating even as recently as 1952 had the vision and the wisdom to project accurately the future because our needs are so great, our population has grown so much, and world conditions have changed to such an extent even in a few years that we have to constantly examine what our resources are and what we are going to do about them.

That is about all I have to say now, Mr. Chairman. I appreciate most deeply that both you and Senator Martin and your staff could be here this morning.

The CHAIRMAN. I think it might be well for us to introduce our staff, Senator Carroll. We have a very excellent staff on this committee. Many of them we have borrowed from other agencies of the Government and operating on the basis of obtaining the most comprehensive information and at the least additional cost.

We have been especially fortunate in securing the services of Mr. Schad, as the director of our committee's work. Ted, would you stand up and be recognized, and then introduce the others here of the staff that are with you?

Mr. SCHAD. I will be very glad to do that, Senator.

Serving as consutant in an advisory capacity to our committee, we have Johnny Mutz, who is assigned to us from the Public Works Committee. Many of you are aquainted with Johnny.

We have also borrowed from the Public Works Committee our chief clerk, Paul McBride, and, of course, for handling this hearing we have just turned that job right over to the Colorado Senators and Harry Schnibbe has made a great many of the arrangements with the help of the Colorado people.

Senator Hart, of Michigan, is one of our members and he has assigned Miss Muriel Ferris to work with the committee and help us

out in connection with our analyses of this work. Senator Anderson, of New Mexico, has assigned Doyle Kline to work with us. We also have some of our own consultants here today, Ed Ackerman, who is serving a few days every month with us, and Mr. W. G. Hoyt, who retired from the Geological Survey some years ago and is serving with us as a consultant. Senator Kerr has given us the use of one of his secretaries for each of our hearing trips and we have Miss Peggy McCormick here today. She is sitting in the back of the chamber. We are very glad to have Peggy with us today. And sitting behind the pillar there is our Army escort officer, who makes this trip possible by taking care of all the logistics, Col. Stan Kimmett.

And I also want to introduce our reporter, who can take testimony 7 or 8 hours straight without even stepping outside—Frank Smonskey, with the Alderson Reporting Co.

The CHAIRMAN. Thank you, Ted.

Senator Carroll, if you will call your witnesses.

Senator CARROLL. The first witness will be the Governor of the State of Colorado.

STATEMENT OF HON. STEVE McNICHOLS, GOVERNOR OF THE STATE OF COLORADO

Governor MCNICHOLS. It is good to see you here, Senator, awfully nice of you to come, glad to have you, John.

The CHAIRMAN. Governor, we are glad to see you. You are one of the reasons why we came to Colorado.

Governor MCNICHOLS. I thank you, Senator. We are awfully glad to see you here. I can tell you that.

Senator CARROLL. I want to say, Mr. Chairman, for the record, that Governor Steve McNichols has been not only one of the leaders in the fight for development of water resources in Colorado, but all over the West. He has acted not only as a State official who is fighting for his own people in his own State, but he has gone throughout the West to unify the Governors, of whatever political party, on a great water conservation and utilization program.

And his own record in Colorado is outstanding in providing leadership for the legislature, in appropriating money, and in seeing that the funds were well used in water resources planning.

This is something almost new in Colorado, his use of State money in cooperation with the Bureau of Reclamation and U.S. Geological Survey.

The CHAIRMAN. Does Mr. Sparks have the percentage of the area of Colorado which is federally owned?

Mr. SPARKS. I do not, Senator, but I will be glad to get the figures for you. It is a very large percentage.

The CHAIRMAN. Yes, I know it is.

Mr. SPARKS. I will be glad to furnish that or any other type of information I am sure we have readily available that this committee may now desire or desire in the future.

The CHAIRMAN. Fine.

Is there someone in the room who could supply that information at this point?

Mr. SPARKS. Mr. Kimball, perhaps.

Mr. KIMBALL. Senator, I believe it is approximately 40 percent of the State; maybe a little over that, 44 percent.

The CHAIRMAN. Of the total area of how much?

Mr. SCHAD. 104,000 square miles.

The CHAIRMAN. You would say approximately 40 percent of that is federally owned?

Mr. KIMBALL. Yes.

The CHAIRMAN. Thank you very much.

Pardon me, Governor.

Governor MCNICHOLS. That is all right, Senator.

Both Senator Kerr, Senator Martin, and our distinguished Senator Carroll, I want to congratulate Mr. Sparks on the fine statement he has prepared for the committee.

Mr. Sparks is typical of some of the talent that we have in our resources department.

I want to say also, Senators, that the people of the State of Colorado have followed with great interest the activities of this committee. This interest is readily understandable when it is remembered that our climate is semiarid and that a large part of our eastern plains have the unfortunate distinction of being classified as a chronic drought area.

Tremendous competition exists here within the State over the available water supplies. Add to this internal competition, the demands of other States for waters originating here, and you have water resources as our major problem.

We warmly welcome you to this State. We congratulate the U.S. Senate on taking this approach to explore the water problems of this country.

Without question, the findings of this committee will be a revelation to everyone. We shall look forward to those findings being translated into positive action.

There is such a great interest here in Colorado in this hearing today that it was not possible to schedule the many witnesses who would like to appear.

I think you will find, however, that we have arranged for a broad coverage of our water resource problems, with as much specific information as time permits.

There are witnesses here today who are far better qualified than I as technical experts in the field of water resources. However, in my capacity as chairman of the Colorado Water Conservation Board, I have been able to learn firsthand of many of our State and National water problems.

I would like to say in that connection outside of this statement to the committee that Colorado has done in the last few years everything that it could in order to develop its own resources machinery and in order to appropriate additional funds to carry out that resource program.

For instance, we at one time here had 18 or 19 resource agencies and the legislature 2 years ago passed a resource bill which combined all of these resource agencies into one agency and enabled us to appoint a director who could coordinate all those activities.

We had the unfortunate experience here over the years of having one agency in conflict oftentimes with another agency.

This made it very difficult for our congressional delegation and for the Congress itself to really find out what Colorado wanted in the way of resource development.

Through this coordinated resource department we hope henceforth that we can come before these congressional committees with a unified approach, Colorado being unified on what it wants.

When we send people to testify before this great committee of the Congress they actually represent the resource policy of this State and not any diversified policy as may come out of any individual agency.

All of our problems will be, we hope, ironed out at home. We have increased our appropriations and tried to initiate a policy of some self-help in addition to what we asked the Government for. But, as you know, Senators, this State is a relatively low population State.

In the past our assessed valuation has not been as high as some of our more developed and industrialized areas. Yet we have these great problems confronting us. We are the mother of the waters of this area.

I think there is only one river that runs across the northwestern corner of our State that runs from another State to our State. All of the waters run out of Colorado into other States. These great watersheds of ours supply water for the Nation east and west.

The CHAIRMAN. Governor, with reference to that coordination of your many agencies into one and the unification of the effort, I must say if you succeeded in that I hope some President puts his finger on you to do the same job in the Defense Department.

Governor MCNICHOLS. That is an aim and objective and it is experimental, I must say, at this point.

But I want to congratulate our various agencies, our fish and game and water conservation, our forestry department, our agriculture department. All of our departments have entered into the spirit of this thing with the idea in mind that we are going to do what is in the interest of most of our people, and I hope that we won't be provincial about it in Colorado and will be asking something that is not in the interest of this entire Nation.

We don't want to be provincial. We want to understand the entire problem.

I wish to emphasize at this point that the natural water resources of this State would probably be sufficient to satisfy our population for over a hundred years to come if it were not for the needs of other States. These needs, as well as our own, continue to grow.

Yet while interstate quarrels over water supplies continue unabated, millions of acre-feet of water are discharged annually into the oceans surrounding this continent—unused and unclaimed.

Plans and projections involving the transbasin diversions of water are often ridiculed. Let it be remembered, however, that such transbasin diversions have been employed in Colorado for over 50 years.

Bordering on and west of, the Continental Divide, there is scarcely a State today which does not employ or contemplate the transbasin diversion of water.

This committee is meeting today in the Atlantic Ocean watershed. Yet a large part of the water you will consume and use here in Denver came from the Pacific Ocean watershed.

I am sure that this committee in its travels has been impressed with the fact that those States of the West classified as arid and semiarid have little or no water to spare. It is our conclusion here in Colorado that no Federal planning concept can be complete without active and imaginative consideration of major transbasin diversions from those river basins where tremendous amounts of water are being wasted to the oceans.

I mean by that, Senator, if I may digress a moment, that I think those of us in this room will, I hope they will, live to see the day that the water now is wasted into the ocean, the fresh water, that someday we will find a way to divert that water for the use of this Nation.

The transbasin diversion of water and the interbasin diversion of water, I think, is something that ought to be put on the drafting boards of the Interior Department.

In the last few years, it seems to me that little or no thought has been given to this tremendous problem.

Certainly it is going to cost some money, it is going to be expensive, but these water resources are our most important resource as you stated so ably last night, Senator Kerr.

It seems to me that in the year of 1959 that better than a million acre-feet of fresh water ought to be coursing down the Snake River down into the Columbia River and into the ocean. There ought to be some way that the engineers and the technicians and that modern science engineering science would find a way to divert that water to areas where it is needed.

I think that our administration, with all due respect to it, has lacked the vision and has lacked the fortuity to tackle this problem, largely, I think, because they fear the expense is going to be too great.

As you pointed out last night, this entire Nation is suffering depletion of water supplies and those areas that are not arid or semiarid, as we are, are now beginning to feel the pinch of the lack of water.

I think that our Interior Department ought to put back to the drafting boards some of these great imaginative projects that would perhaps transfer water from the great basins into other areas where it is needed, assuming that we don't take needed water from any area. We are all jealous of our water. We are jealous of our water in Colorado River Basin, but I think no one can say that Colorado has not been cooperative and that Colorado has not been more than generous in dividing up her water. We have sent 11 different compacts, I believe, with other States, calling for the diversion of our water.

In the past both the State and Federal Governments have attempted the development of water resources on a river basin concept, with varying degrees of success. The current development of the Upper Colorado River Basin is an outstanding example of interstate and Federal cooperation.

There is an urgent need, however, for a priority system to be established in developing the respective river basins. All developments have heretofore been the victim of conflicting State interests and vacillating Federal policy.

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I find this, to get away from the statement again for just a moment, I find this in the administration. We found half a reluctance and hesitancy on the part of the administration to authorize projects. I am not talking about appropriating for them; I think they have a hesitancy to authorize projects and slow them up because they are afraid that the various areas of the country are going to come in and ask for appropriations to build these projects.

Everyone's project is important to them. The Colorado River is important to us. The Fryingpan-Arkansas is important to us. The Missouri Basin development is important to its residents; the Columbia River Basin is important to its residents; and the Tennessee Valley, and all of them.

I don't see why we have to fear the allocation of money for research and investigation in order to get projects in shape, get them to the feasibility stage, merely because there is a fear that the various areas might come into the Congress and ask for appropriations to have these projects constructed.

I think we could allay the fears of the administration and the Bureau of the Budget and all of these people who in Washington now seem to have more interest in balancing this budget than they do in developing the economy of this Nation.

By setting up some reasonable systems of priorities, the different water systems have to come in and compete with one another for funds. I think that if we would have a full blown program of investigations and development with the idea that we are going to declare as many projects feasible as we can, and then have representatives of the various river basins sit down and set up a priority among themselves and try to dovetail those priorities with one another so that there will be an orderly development of each river basin. That is not beyond the realm of possibility.

In the last 3 or 4 years the Governors of the upper basin States, including Colorado, Wyoming, Utah, and New Mexico, and the water departments of those States have gotten together so that now we don't come into the Congress of the United States only asking for the development of Colorado projects or Utah projects or Wyoming or New Mexico. We have sat down together and tried to work out a system of priorities and orderly development of our basin so that each State and each area gets some kind of development.

We have gone into a joint basis asking for the development of each other's projects, testifying for one another.

And so far we have had an orderly dispersion of those projects, not as accelerated as we would have liked them, but, nevertheless, there has been complete cooperation.

It seems to me that those of us in official positions that call for statesmanship ought to be willing to sit down with the other people in other basins and with these great congressional committees and try to work out this system of priorities so that this Nation, as a whole, in the interest of its defense, in the interest of its economic and resource development, could come up with some orderly program.

It may involve quite a bit of money, but it seems to me that if we can spend great sums of money all over the world in developing underdeveloped countries (and I am for that, I believe these underdeveloped nations ought to have some development), then I cannot see any con-

sistency in saying to our own people in this Nation, "You are going to have no new starts; you are going to have no reclamation, no resource development," and build our competition throughout the world and yet inhibit our own development.

This, to me, is a national tragedy.

Getting back here to the statement, as the members of this committee have observed firsthand, the development of our water resources has largely been on a year-to-year basis, without common control or purpose.

The various competing States, including Colorado, have contributed little in the way of orderly planning for water resources development on a national level. Despite our past and present activities, we feel that both the State and Federal Governments must determine a workable and logical priority of water resource development which will best promote the national interest.

In Colorado we are particularly impressed with the necessity for discovering new sources of water, and for conserving and reusing those supplies already available.

With our limited financial resources we are pressing basic research in various fields ranging from research in solar activities as related to precipitation effects, to the reduction of carriage losses by canals and ditches. Such research is costly, but an absolute necessity nevertheless.

Virtually all lines of research into water problems are of benefit to all parts of this Nation. This field of activity has too long been neglected by both the Federal and State Governments.

I was amazed, getting away from the statement again for a moment, I was amazed the other day when the Under Secretary of Interior came to Colorado and made the pronouncement that the West was going to have to find and have to rely more on its own resources for its water and resource development.

Now, as I previously stated, these are low-population areas presently, but mushrooming tremendously. We are getting from thirty to fifty thousand new people a year in this State. These projects that we are talking about, they are projects that are self-liquidating, just like our Big Thompson project. We ask for the credit of the Government; in most cases, almost all, only a negligible amount is not repaid to the Government.

These are wealth-producing projects. These are projects that are going to produce taxation. They are going to produce a good economy. They are going to produce livelihoods for these millions of people that are going to come to the West.

And for our Government to come out here, the western part of the United States, this resource-rich area, this virtually untapped area, resourcewise, and tell the people that they are going to have to depend on less and less help in these vital and important areas, that these Western States could not possibly pursue even if they wanted to, we don't have that kind of money, we don't have that kind of opportunity to do these basic research jobs that I think are a legitimate area for the Federal Government to come out and help develop this nation.

When this country gets in trouble and its security is involved, or when we find that our safety is in danger and our people are in

danger, you cannot come out to the West and put spigots in the hill and get metals, basic and strategic metals.

It takes a long time to develop them. We have to inventory these resources and find out where they are. We have to have power to develop them, and industry follows the power.

For our own Interior Department to come out and say, "You can look for less help in this area," I think that is a national tragedy also, because we can't accomplish this development with our own resources.

Increased activity in the research field has already been evidenced by the Congress in its authorization of the desalinization program and soil moisture laboratories.

I wish to state that it is my personal conviction the Congress should continue to expand upon these Federal research activities. It is not within the financial or technical ability of an individual State to conduct extensive and conclusive research in the many required areas.

Almost 25 percent of our State budget for water resources is now devoted to research. A major portion of that amount is being spent in ground water research under a cooperative agreement with the U.S. Geological Survey. Without the technical and financial assistance of that agency, we could accomplish little.

With a little more help, I might add, we could accomplish much more. For instance, our ground-water research program, our share, I believe, of that project, is what, two million? The total program?

Mr. BERNARD. About that.

Governor MCNICHOLS. I think it was about $2 million.

We have a water budget just for our water development of somewhere around a half million dollars, very close to half a million dollars.

To tell us that we have to come up with a $2 million State budget to accomplish the type of underground research that we want to accomplish is fantastic. This is important.

This supplemental water, as a matter of fact, I think it is a major source of water for this area. If we had to do it on the basis of what we could appropriate now, it would be at least 20 to 30 years before we could ever come to any conclusion whether or not these groundwater reserves could be used to supplement our surface waters.

It is a tremendously important thing, and I think it is an area that we could well spend some money and the Congress could well spend some money.

Getting back to the statement, the basis for any program, water resource or otherwise, is prior investigation. We were, therefore, greatly concerned when the funds appropriated to the Bureau of Reclamation this year were insufficient to maintain the previously established level of field investigations. We have tried to remedy this deficiency to the best of our ability with State funds.

This effort consumed an additional 25 percent of our water resource budget, and we were still not able to hold the field offices at their previous level. This up and down fluctuation of trained personnel adds materially to the cost of every project.

It is not unusual for even a small Federal project to be in the investigation stage during a period of from 5 to 10 years. When the final report is completed much of the accumulated data may already be out of date.

In addition to financial limitations and State indecision, the administrative processes of the Federal agencies are incredibly slow.

On our Colorado River projects there are three Federal agencies which share major responsibilities in the investigation of any given project: the Department of the Interior, the Department of Agriculture, and the Corps of Engineers. The functions of these agencies in relation to water projects do not only overlap in many instances but in some cases are identical.

The result, of course, is delay, contradiction, and greatly increased costs.

Again to get away from the statement a moment let me say that I think that the administration and the Bureau of the Budget have used this device because you have to have the reports of these various departments before any of these projects can be declared feasible. You can have all of the information safe and, except, let's say, for example, the report that is due from the Department of Agriculture.

Through administrative slowdowns and dragging their feet these reports sometimes never come in. Then the Interior committees of both the Senate and House tell us we cannot do anything with this until we get this report from the Department of Agriculture, so that the Bureau of the Budget can put it in the budget and then that budget will come to the Congress. The Senate hasn't paid much attention to that kind of thing. The Senate has been most considerate.

But the House seems to think that unless the Bureau of the Budget has the item in the budget that nobody can do anything about it.

I can see the logic to that. The Congress does not want to appropriate money until the feasibility problems connected with the project are determined.

But when the administration, this is not for appropriation of construction of the project, this may be for a provision of money for investigation or something to complete the report, but the administration uses these devices as slowdowns so that they won't have to face these problems of future appropriations for construction.

I think there ought to be some way that the Congress could devise some method whereby these reports would have to be completed within a certain length of time; that they should say in affirmative language, the reports shall be completed irrespective of whether we appropriate money for the construction of the project.

If it is a matter dealing with authorization and feasibility, there isn't any reason why we cannot face up to the fact and know at an early date whether it is feasible or infeasible and then we don't mark time on our investigations, waste money on this end, the Interior Department waste money on their end, trying to find out what the facts are in connection with these projects.

This country, as we all know, exists because of the union between the States, crystallized into a government of all of the people.

We here in Colorado realize and fully accept the fact that any project of Federal scope must be subjected to Federal regulation. There are infrequent occasions, however, when we have had cause to question the wisdom of Federal agency policy on specific water projects. Needless friction, for example, was recently caused between this State and the Department of Interior because of lack of information coming to us on the transmission and allocation of hydro-

electric power from units of Colorado River storage project. This situation has not yet been completely remedied.

We in the States expect a full partnership with the Interior Department on all information, certainly with respect to the allocation of power and transmission lines. The allocation of power is tremendously important to us because it is the power and the water that are going to pay for these projects, the multiple-use projects.

If the States are not going to get all the information on the power allocation, and all the information surrounding the transmission lines, and are not going to get it before some private power companies and other agencies start stringing the powerlines, we don't feel that we are a full partnership in this thing.

It is important to us and to our people, and I feel that the Interior Department ought to make full disclosure at all times on these matters concerning the allocation of hydroelectric power from the units of the Colorado River storage project, or any other storage projects.

One other thing I would like to mention in closing.

I think that the subject of topographic mapping and some things that we are behind on are also very important things. I had the occasion during the summer to visit Russia and I found that in their topographic mapping they have the country mapped down to a point where it is tremendously important to them in their resource development and I doubt that a third, or 20 percent, for instance, of this State is topographically mapped and explored.

I think we in this Nation ought to do something about the inventory of our resources, but the topographic mapping of our country, a full-blown investigative program on what resources we have, and there ought to be some effort, I think, made to dovetail the efforts of this country with the other free nations of the world so that the free world will have an accurate inventory and estimate of its resource development and resource potential.

Again let me say I am deeply appreciative for the opportunity to express my views to this committee. I don't want to be duplicating other information that will be given here, but I want to say, on behalf of all the people of the State of Colorado, we are deeply grateful to you and this committee for taking your time to come here and listen to our problems which we feel are important problems not only to us and to our own personal development in this area, and we feel that we could make a great contribution to the security of this Nation if some of these problems were translated into action.

Thank you, Senators.

The CHAIRMAN. Thank you, Governor.

Senator CARROLL. Thank you, Governor.

The CHAIRMAN. I want to say that in my judgment when we get as nearly as we can a knowledge of the sum total of all the problems in all of the States of the Union with reference to development of their water resources, that we will have made available to the Senate and the Congress the basis of the greatest opportunity for future service in the field of resource development.

Governor MCNICHOLS. That is certainly true. That is certainly true, Senator.

Senator CARROLL. Thank you, Mr. Chairman. Is Dr. Morgan here? Will you step forward, please.

Mr. Chairman and members of the committee, this is Dr. Morgan, president of Colorado State University. Dr. Morgan is not only one of our leading educators and thinkers, but has great knowledge of basic research relating to water resources and we are very fortunate to have Dr. Morgan here this morning.

The CHAIRMAN. Very good, Doctor.

STATEMENT OF WILLIAM E. MORGAN, PRESIDENT, COLORADO STATE UNIVERSITY

Mr. MORGAN. Thank you, sir.

Mr. Chairman and members of the committee, first, may I express to you my appreciation for this opportunity to present a statement to you on this subject.

I should also like to thank Senator Carroll for his very kind words.

Senator CARROLL. I could have extended that, but I wanted to save the time. Colorado knows you well and I am sure the Senators here know you, too, Doctor.

Mr. MORGAN. Thank you, sir.

Mr. Chairman, I plan to start with the first page of this statement and then to abstract it in my comments.

The CHAIRMAN. Your entire statement will be made a part of the record, Doctor. You make such use of it in your statement as you see fit.

(The statement referred to follows:)

STATEMENT BY DR. WILLIAM E. MORGAN, PRESIDENT, COLORADO STATE UNIVERSITY

> "The conservation and use which we make of the water resources of our Nation may in large measure determine our future progress and the standards of living of our citizens. If we are to continue to advance agriculturally and industrially we must make the best use of every drop of water which falls on our soil, or which can be extracted from the oceans."—From President Eisenhower's letter of transmittal to the Secretary of the Interior covering the water resources policy report.

In Colorado and in nearly all the West this is already a truism. The availability of water is the architect of our present and future development.

From testimony which you have heard in the past 5 weeks you already are aware of the major water problems of the West.

We at Colorado State University wish to enter a plea for an expanded program of research and education to find and apply solutions to these problems.

Throughout the nation the demands for water are ever-increasing while the natural supply remains nearly constant. Attention currently is focused on research to develop new supplies of fresh water.

Scientists are experimenting with techniques for increasing rainfall by artificial nucleation or cloud seeding. They are seeking more economical means of reclaiming saline waters. Although we look hopefully to such measures, they are not likely to provide large scale relief to much of the West.

In large part the solutions to or abatement of our water problems must be found through conservation of our present natural water supply. Three lines of action are available to us: (1) conservation of the supply; (2) conservation of use and (3) conservation of quality.

Our present natural water supply is found in surface streams and lakes and in underground reservoirs. Throughout the West, much of this supply originates in our mountain watersheds. If we can prolong the period of surface runoff, increase water recharge and reduce losses resulting from seepage, evaporation, and transpiration we can conserve this original supply.

Many methods are being developed toward these ends. Surface waters are stored in man-made reservoirs ranging in size from farm ponds to lakes covering

thousands of acres Crop rotations, contour plowing, and maintenance of ground cover and organic matter contribute to the storage of soil moisture.

Research by the U.S. Forest Service indicates that under certain conditions, a change in forest cutting and harvesting practices may bring increase water yield from one-fourth to one-third. Of potential significance particularly in the mountainous West are current research studies in snowpack management. The objective is to determine the effects of induced snowdrifting upon the timing of peak streamflow. Should snow management prove practical and economical the savings in evaporation losses would be tremendous and the need for additional reservoir storage facilities would be reduced. Cetyl alcohol or hexadecanol is now being tested as a means of reducing evaporation losses on reservoirs and lakes. The development of a satisfactory evaporation suppression agent would contribute greatly to water conservation in the West.

Research has revealed that tremendous water losses may be attributed to vegetation growing along streams and watercourses. The U.S. Geological Survey showed that these phreatophytes consume 20 to 25 million acre-feet of water annually in 17 Western States. This loss, to plants of little economic value, exceeds the average annual flow of the Colorado River by 5 million acre-feet. To salvage some of these losses, additional studies to find economic means of eradicating such vegetation are indicated.

Watershed improvement and rehabilitation and flood protection programs on both public and private lands currently are being conducted. The effects of these programs in terms of water yield require investigation.

The greatest savings in water will probably come from more efficient use of our present water supply. Elimination or reduction of waste will go far toward reducing our apparent demands for water. As much as 60 percent of the total water diverted for irrigation is lost in transport or lost to evaporation and deep seepage. Research to find ways of reducing these losses is sorely needed. A reduction of only 30 percent of the current losses would amount to an annual water savings of approximately 21 million acre-feet.

Despite the fact that more effort probably is being expended to reduce waste in irrigation than in other use categories, the agriculturist often receives the greatest blame for water wastage. For the average citizen, assigning the responsibility for the entire situation to this one group is probably a most comforting thought. Yet no one can ignore evidences of municipal waste which occur in every home every day. There is excessive use of water for car washing, lawns are overwatered, water-wasting air-conditioning units which could be replaced by mechanical refrigeration are employed. New York City provides a startling estimation of loss through leaking mains and dripping faucets alone. This city wastes 200 million gallons of water per day to this source—225,000 acre-feet per year—almost the equivalent of the combined capacities of our Carter and Horsetooth Reservoirs. Such losses are of course not limited to large cities or to any one geographical area. They are nationwide. They are correctable. A comprehensive effort is needed to educate all people both as to their personal responsibility in conserving water and in ways and means of effecting such conservation (a program similar to our fire prevention program starting in the elementary school may soon be in order).

Waste should be stopped, but further, the water which is used must be used efficiently and effectively. Current estimates indicate that by 1975 we will have 220 million persons to feed in the United States alone. This number is expected to rise to 300 million or more by the year 2000. Increased yields in food and fiber are an absolute long-range necessity. Research on improved agronomic practices, soil characteristics, and more efficient irrigation systems must be carried out. We must through plant breeding develop species which are capable of higher productivity without increased use of water.

One example of this type of research is cited. Investigations by the Colorado Agricultural Experiment Station demonstrated that the usual irrigation of corn toward the end of August actually reduced the yield. This last application of water, amounting to approximately 1.5 inches per acre could then be used to irrigate an additional 81,000 acres of corn under Colorado conditions. Present modest research efforts indicate that additional savings in water can be effected by certain cultural, fertilizer, and genetic applications.

One of the greatest opportunities for water conservation lies in the maintenance of water quality. Sewage, industrial waste, sedimentation, increases in water temperatures, and, locally, intrusion of salt water or brines adversely affect this quality standard.

Some 10 years ago the U.S. Public Health Service surveyed 11 major river valleys in the United States covering 4,409 municipalities and 3,418 industrial plants. The survey showed that 57 percent of the industrial plants and 43 percent of the municipalities were still discharging raw, untreated sewage into the streams. In many areas apparent water shortages are actually the result of inadequate quality of available water. If one city fails to treat its sewage before readmitting it to a stream, a community or industry downstream must then seek an entirely new supply:

Not only do untreated effluents contaminate the water itself, but, particularly in the case of large cities, they may in effect "seal" the bottom of the streams. Normal recharge of ground water is inhibited and ground water levels are lowered as a result. Overloads of detergents, and chemical and organic effluent in sewage commonly prohibit the use of water downstream for irrigation purposes and further destroy the recreational and esthetic values of the downstream stretches of the river. Stream temperatures well in excess of 100° F. have been recorded even during the winter months as the result of heavy industrial use of water for cooling.

At present 82 percent of the total water use in the 17 Western States is for irrigation purposes. However, increasing municipal and industrial use is inevitable. Means should be developed now to use and reuse the water and effluent from our cities and factories.

Development of a means of disposal whereby industrial and municipal waste waters and effluent can be applied to agricultural lands is particularly important. We must discover which soils and crops are most readily adapted to this operation. We must be able to correct any harmful effects to the soil or to persons consuming crops thus watered or fertilized.

Positive steps are being taken by many cities and industries today to conserve water quality through improved treatment of sewage and recycling and reuse of industrial water. For example, total water consumption loss per day at Kaiser Steel in Fontana, Calif., has been cut to the 1,800 gallons actually lost through evaporation; the remainder of their vast intake is recycled and reused for cooling. Bethlehem Steel uses treated sewage water from the city of Baltimore for industrial cooling.

The additional cost of purifying water for such reuse frequently can be offset by capitalizing on the useful byproducts which result. Fertilizers and gas are two of the most commonly recognized of these byproducts.

Streams differ in their size, flow, and biological characteristics. Consequently their ability to absorb impurities varies. The kinds and volume of waste entering a stream must be considered. We must know how much these materials are diluted by the water entering with them. Variations in streamflow and in seasonal loads will make significant differences in the handling of a problem area.

Although research by the Public Health Service, implementation of the Federal Water Pollution Control Act of 1956, and the strengthening of water pollution laws all point to an improvement in the conservation of water quality, the job ahead is tremendous. Our potential for progress is also tremendous if our research, particularly in industrial and sanitary engineering, develops better and more economical ways to effect improvement of water quality.

Soil erosion and its attendant sedimentation are further enemies of water quality which must be combated. In fact, siltation not only depresses water quality, but actually robs us of agricultural land through reduction in fertility or through aggravated flood conditions. Because of siltation it is estimated that one-fifth of the Nation's 2,700 water supply reservoirs have a useful service life of under 50 years. Geologic and man-induced erosion furnish the silt. Poorly managed farms, forests, and grazing lands, particularly in hilly and mountainous areas, are frequently severely eroded. We have allowed conditions to develop which are harmful to agriculture, restrictive to industrial growth, and dangerous to our entire water resource. These conditions can be corrected through watershed maintenance and watershed rehabilitation. Studies are needed to learn how to reduce sediment reaching diversions and storage reservoirs. In connection with watershed studies research is needed on ways of extrapolation from trial watersheds to full basins.

The application of conservation practices to all our lands can do much to effect an improvement in water quality. Again, additional research is needed to provide guidelines to the most efficient and economical means of accomplishing such conservation. Municipalities and industries are required by law to

clean up the water. In the case of pollution by sedimentation, it is only possible to provide technical assistance and to recommend that conservation practices be followed.

Public and private conservation agencies and educational institutions have made outstanding efforts to spread a philosophy of conservation. Government subsidies have been directed toward the same objective. Despite these efforts our progress in encouraging conservation certainly cannot be measured in jet-speed terms.

Another of today's major problems and one with which I am sure you are already familiar, deals with the administration and control of our water resources. Our present legislative vehicles for administering water use are all too often of horse and buggy vintage at the Federal, State, and local levels. A rapid expansion in population dictates the need for modern vehicles to meet the conflicts in demands and to provide for expansion of agriculture and industry.

A continuing shift to urbanization and increased leisure time and higher living standards will be marked by an increase in recreational demands for water. Our present laws and our methods of economic analyses for water developments are woefully inadequate, particularly in regard to recreation.

In the case of the problem cited above some research is already underway. However, it is often piecemeal, uncoordinated, or woefully inadequate. A vastly expanded research program in all phases of water resources offers the greatest promise toward meeting the demands for more water.

It is not likely that a panacea for all of our water problems will be found. It is essential, however, to understand the nature of the forces creating the water problems which we do have. We are being pushed into action programs by the pressure of public opinion and all too often we must rely largely on intuition or must resort to trial and error techniques to accomplish a given objective. Both expedients are often wasteful of both time and money.

We have a moral obligation to stockpile knowledge so that it may be available whenever the inevitable demand for it arises. We can develop the skills to solve the water problems if the public recognizes its responsibility in conserving water resources and if it will support the research and finance the educational effort necessary to translate new knowledge into action on every farm, forest, and in every municipality and industry.

A worldwide reputation has been established at Colorado State University during the past half century as a result of its leadership in the water resources fields. Significant research contributions have been made by the university in hydraulic and irrigation engineering, in ground water hydraulics, drainage of urban and irrigated lands, and in conveyance, distribution, and management of irrigation water. Outstanding work is being done in hydrometeorology and climatology, particularly with evaporation phenomena. Projects are underway on seepage in canals and reservoirs, waterflow measurement, canal erosion and sedimentation control, and river control engineering.

Since water is the principal factor limiting crop production in the West, considerable research effort has been conducted and is now being expanded by the university in the area of water-soil-plant relations. The basic principles underlying (1) water use by plants, and (2) the efficiency of utilization of both irrigation water and the limited natural precipitation in nonirrigated areas are being sought.

A few examples of the type of research being conducted at Colorado State University in this area are methods to increase intake of precipitation and irrigation water into soils, efficiency of use of water by plants, reclamation and maintenance of alkaline and saline soils, and drainage. Soils deteriorate and crop yields are reduced when water is wasted. Current research holds considerable promise of finding ways to reduce or eliminate such waste. Efforts in these areas of research must be more fully supported if we are to find answers to these problems.

Professional training in natural resource management was started at Colorado State University in 1909 with the establishment of a foresty curriculum. The institution, however, appointed its first professor of irrigation engineering in 1886. Facilities and educational and research programs have been expanded to include range management, wildlife management, fisheries science, forest recreation, and forest utilization. All are intimately associated with water use and water resource management.

With a grant from the Charles Lathrop Pack Foundation and the cooperation of the Forest Service a new program in watershed management with training

to the doctorate level, the first of its kind in the world, was established in the college of forestry and range management in 1958. We are now training research specialists and technicians for work in the water resources fields.

Current research in forestry and range management is concerned with the determination of land management practices which are compatible with maintaining desirable watershed conditions including brush control, revegetation, and grazing practices.

Colorado State University is ideally situated to provide professional training and research experience in water resource management, and, of course, can rely upon its agricultural extension service for dissemination of new knowledge or techniques the translation of them into action programs. A natural laboratory at our back door provides climatic, vegetative, land use, and physiographic conditions ranging from semidesert to artic tundra. Within our State four of the Nation's major river systems are born. Our alpine snowfields are the principal water yield areas for the Colorado, Rio Grande, Platte, and Arkansas Rivers. The significance of the management of Colorado's watersheds and water resources becomes strikingly evident when one realizes that water originating in Colorado is used from Los Angeles to the Mississippi and from Wyoming into Mexico. Thus our treatment of the water resources and the lands from which they flow has tremendous national as well as regional and local import.

Offices of a number of Federal and State agencies which are concerned with the use and management of the water resource are located on or near the Colorado State University campus. We feel that our educational and research programs are immeasurably strengthened by our active association with these agencies. The university currently is engaged in cooperative research with the U.S. Forest Service, Agricultural Research Service, Bureau of Public Roads, Office of Naval Research, Department of the Army, U.S. Geological Survey, Fish and Wildlife Service, and the National Science Foundation. The university's contribution to cooperative research includes participation by staff and graduate students, consultation services, library facilities, housing and laboratory facilities where practical, and often direct financial contributions. We feel that these cooperative efforts are extremely desirable and mutually beneficial.

Included in our plea for an expanded research and educational program is the recommendation that whenever and wherever possible research programs be conducted in cooperation with our universities. Our obligation is twofold. We must train both the scientists who will staff the research and educational agencies and the technicians who will translate research results into action programs. In addition, we disseminate the results of research to the public through our classrooms and our extension service. Our task as well as that of the research agencies often can be accomplished most efficiently and economically through cooperative effort.

In conclusion we wish to leave with the Senate Select Committee on National Water Resources the following specific recommendations:

1. Additional Federal support should be made available to State experiment stations and other interested agencies for both local and regional research in water resource development, management, and utilization. These research fields should extend from the atmospheric sciences to regeneration and use of polluted waters.

2. Restatement of our earlier recommendations relative to facility needs for soil moisture conservation research for the central Great Plains. (See S. Doc. No. 59, 86th Cong., 1st sess., "Facility Needs—Soil and Water Conservation Research," pp. 75–79 and 135–136.) It is our considered judgment that a Great Plains Soil Moisture Conservation Laboratory is a fundamentally important and urgent need and should be given highest priority in the development of future programs.

3. Recommend research center for water conservation in the upper Colorado River and Rocky Mountains. (See S. Doc. No. 59, 86th Cong., 1st sess., "Facility Needs—Soil and Water Conservation Research," pp. 65–69.)

4. Expansion of present Federal program of forest and range watershed management research. This should include laboratory facilities for snow investigations in the central Rockies.

Mr. MORGAN. Yes, sir. It is my intention to stay within the time limit that was set for me and so if you are attempting to follow the

statement as I talk, I am afraid after the first page, you will get lost, because I do expect to abstract the main body of the statement and then conclude.

The CHAIRMAN. The only way I will get lost is for you to get lost because I am going to stay with you.

Mr. MORGAN. All right, sir. Thank you very much.

President Eisenhower's letter of transmittal to the Secretary of the Interior covering water resources policy report states:

> **The conservation and use which we make of the water resources of our Nation may in large measure determine our future progress and the standards of living of our citizens.**
>
> **If we are to continue to advance agriculturally and industrially we must make the best use of every drop of water which falls on our soil, or which can be extracted from the oceans.**

In Colorado, and in nearly all the West, this is already a truism. The availability of water is the architect of our present and future development.

From testimony which you have heard in the past 5 weeks, you already are aware of the major problems of the West.

We at Colorado State University wish to enter a plea for a comprehensive program of research and education to find and apply solutions to these problems.

Throughout the Nation the demands for water are ever increasing while the natural supply remains nearly constant. Attention currently is focused on research to develop new supplies of fresh water.

Scientists are experimenting with techniques for increasing rainfall by artificial nucleation or cloud seeding. They are seeking more economical means of reclaiming saline waters.

Although we look hopefully to such measures, they are not likely to provide large scale relief to much of the West.

In large part, the solutions to, or abatement of, our water problems must be found through conservation of our present natural water supply. Three lines of action are available to us: (1) conservation of the supply; (2) conservation of use; and (3) conservation of quality.

Mr. Chairman, to save time, let me comment on the more extended statement that I am filing with your committee and then I should like to cover the full text of the last 3½ pages of the report.

This statement recites the nature and results of some of the research work conducted thus far in our scratch-the-surface effort along the lines of first prolonging the period of surface runoff;

Second, or increasing water recharge and reducing losses resulting from seepage; and

Third, reducing evaporation and transpiration losses.

The statement calls attention also to the need for an educational program concurrently with research effort and mentions that a program similar to our fire prevention program starting in the elementary schools may soon be in order.

With respect to agricultural uses, the statement mentions that we must through plant breeding develop species which are capable of higher productivity without increasing use of water.

Another example, this one in the area of cropping practices, is the report of investigations by the college experimentation station which

demonstrates that the usual irrigation of corn toward the end of August actually reduced the yield.

This last application of water amounting to approximately 1½ inches per acre could then be used to irrigate additional 81,000 acres of corn under Colorado conditions.

In summary, present modest research efforts indicate that additional savings of water can be effected by cultural fertilizer and generic applications.

With irrigation accounting for 82 percent of total water use in the 17 Western States, this is an area of research that offers the possibility for dramatic returns on adequate investment in research.

However, increasing municipal and industrial use is inevitable and we must without delay get on with research pointing to ways in which economically feasible use and reuse of the water and alluviant from our cities and districts can be assured.

Surely we have the research to apply nature's own law of the conservation of energy to reduce the cost of purifying water for reuse by capitalizing on the useful byproducts which result.

Fertilizers and gas are two of the most commonly recognized byproducts.

The report goes on to mention the obvious sector of research interest in problems of soil erosion and its attendant sedimentation.

Finally, it mentions the neglected area of administration and control of our water resources and some people are surprised when they recognize that research can do something for us here.

Now, may I read from the concluding text of report, this is on page 7 if you care to follow, sir.

In the case of the problems cited above, some research is already underway, however, it is often piecemeal, uncoordinated, or woefully inadequate. A vastly expanded research program in all phases of water resources offers the greatest promise toward meeting the demands for more water.

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1. Water use by plants;

2. The efficiency of utilization of both irrigation water and the limited natural precipitation in nonirrigated areas are being sought.

A few examples of the type of research being conducted at Colorado State University in this area are:

Methods to increase intake of precipitation and irrigation water into soils.

Efficiency of use of water by plants, reclamation and maintenance of alkaline and saline soils, and drainage.

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originating in Colorado is used from Los Angeles to the Mississippi and from Wyoming into New Mexico.

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The university is currently engaged in cooperative research with the U.S. Forest Service Agricultural Research Service, Bureau of Public Roads, Office of Naval Research, Department of the Army, U.S. Geologic Survey, Fish and Wildlife Service, and the National Science Foundation.

The university's contribution to cooperative research includes participation by the staff and graduate students, consultation services, library facilities, housing and laboratory facilities where practical, and often direct financial contributions. We feel that these cooperative efforts are extremely desirable and mutually beneficial.

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2. Restatement of our earlier recommendations relative to facility needs for soil moisture conservation research for the central Great Plains.

More specifically I refer to Senate Document No. 59, 86th Congress, 1st session, entitled "Facility Needs—Soil and Water Conservation Research," and the page reference is listed, sir.

It is our considered judgment that a Great Plains soil conservation laboratory is a fundamentally important and urgent need and should be given highest priority in the development of future programs.

3. Recommend research center for waste conservation in the upper Colorado River and Rocky Mountains. Again I refer to the same Senate document.

Senate Document No. 59, 86th Congress, 1st session, "Facility Needs—Soil and Water Conservation Research," pages 65–69.

We recommend expansion of present Federal program of forest and range watershed management research. This should include laboratory facilities for snow investigations in the central Rockies.

Thank you, sir.

Senator CARROLL. Doctor, thank you for a very fine statement.

Mr. Chairman and Senator Martin, do you have any questions that you would like to ask of Dr. Morgan?

Doctor, on just one point, if the chairman does not mind, I would like to ask: Do you cooperate also with the Bureau of Reclamation?

Mr. MORGAN. Yes, sir.

Senator CARROLL. On your research program?

Mr. MORGAN. Yes, sir.

Senator CARROLL. Yes.

Mr. MORGAN. The history of cooperation with that agency has been a long one. As a matter of fact, the principal building in which our hydraulic research laboratory is now housed on the campus was actually built by Bureau of Reclamation in 1930's as a place to house the testing work that this bureau was doing on some of the early dams that were built in the 1930's, in the Tennessee Valley and on the Colorado and the Grand Coulee.

Senator CARROLL. In the long experience of the Colorado State University, in this field of water conservation and water utilization, do some of your scientists also keep in touch with the scientists in other fields who are doing basic research, for example, Dr. Walter Orr Roberts of the high altitude observatory?

Mr. MORGAN. In that specific instance, very much so.

You see, Senator, this business of research starts off usually as an effort to find an answer to an apparently simple problem. Let's say an engineer starts off on the job. The first thing you know he is involved with the chemist and the physicist and the economist and you even get a sociologist in this once in a while.

Senator CARROLL. The reason I ask the question, if I may interrupt, the Congress in fiscal 1960 appropriated $2 million to the National Science Foundation for basic research in weather modification.

It is a little bit different field than you have been testifying on here this morning.

Nevertheless I also observe that you do cooperate with the National Science Foundation and draw upon them for whatever experience they have, or whatever you can give to them.

Mr. MORGAN. We have a number of projects underway now, the funding for which came from grants from the National Science Foundation, this very fund that you are speaking of.

Senator CARROLL. I see. That is what I sought.

Mr. MORGAN. Yes, sir.

Senator CARROLL. Thank you very much.

Are there any questions, Senator Martin?

Senator MARTIN. No, thank you.

Senator CARROLL. The next witness will be Mr. Thomas Kimball, who is director of the Colorado Department of Game and Fish. Mr. Kimball, Mr. Chairman, is an expert in this field and we are very happy to have him with us this morning.

You may proceed, Mr. Kimball.

STATEMENT OF THOMAS L. KIMBALL, DIRECTOR, COLORADO DEPARTMENT OF GAME AND FISH

Mr. KIMBALL. Mr. Chairman and members of the committee, I appreciate, too, as President Morgan, the opportunity to appear before the committee and present the views of the Colorado Game and Fish Department.

Water is the lifeblood of civilization and as the development of this valuable renewable resource progresses increasing problems will constantly arise as to the conflicts in its use.

The Colorado constitution states that the right to divert and put to beneficial use the unappropriated waters of our streams shall never be denied.

The priorities provided list domestic irrigation and industrial uses in that order.

At the time the Colorado constitution was adopted competition for water was not acute and the demand for sport fishing was so small that many considered our renewable resources to be limitless.

Today, with the population explosion that America is experiencing, the actual reverse of this belief is now painfully evident.

Although Colorado's constitution and State water laws do not adequately recognize wildlife as a beneficial use of water, logical thinking concludes that game fish have and always will use beneficially both the flowing and impounded waters of our State.

This resource has made Colorado famous as a vacation area and plays a vital role in tourism, which is Colorado's third largest industry.

In 1958 the nonresident visitor who attempted to take the wily trout spent $453 individually while fishing in Colorado.

Hunting and fishing itself rang the cash registers of Colorado businessmen to the tune of $81 million in 1958.

The full value of the out-of-doors, and particularly the pursuit of fish and game, cannot actually be measured.

The tranquilizing pill is a poor substitute for the relaxation of an outdoor fishing or hunting trip for the individual who must go the fast pace of modern living in a smog-filled urban area.

Who can say what values this relaxation contributes to the health and well-being of our many citizens?

A great step was taken in recognizing the wildlife values in water use when the Federal Congress enacted Public Law 732, better known as the Fish and Wildlife Coordination Act. This Federal law, as amended in August 1958, calls for equal consideration of fish and wildlife values with other uses in the construction of federally financed or licensed water development projects.

In this State, where we lack sufficient water to care for all of the demands for its use, the wildlife conservation interests are often condemned for efforts made under this law to maintain the quality and quantity of fishing and hunting which have made our State famous.

For the record, then, I would like to cite a few examples of the most vexing problems in which we are currently involved:

1. Most impounded waters which are designed to conserve spring floodwaters fail to provide the necessary round-the-clock

and round-the-year flows of water to adequately sustain fish populations below diversions and reservoirs.

In many instances where these flows are released they are released in such excessively high flows as to cause damage to the fish environment by scouring the channel or making necessary destructive channelization practices.

2. The failure to provide an adequate permanent fishery pool in reservoirs.

3. Fish and game are declared by the laws of Colorado to be the property of the people of the State.

Most water development projects call for diversion of streamflow or the impoundment of water in a reservoir which fluctuates widely as the water is put to its many uses.

These factors are extremely detrimental to the fisheries environment and the production of fish, particularly trout.

4. Attempting to maintain quality hunting and fishing in the face of ever-increasing numbers of sportsmen, and with an environment which is continually shrinking as a result of water manipulation programs and pollution, is an almost impossible task.

In 1958 the Colorado Game and Fish Department sold approximately 245,000 fishing licenses. The Outdoor Recreational Resources Review Commission estimates that by the year 2000 the recreational load on our resources will increase by 10 times.

This means if we are to maintain the quality of fishing we have today in Colorado, in the year 2000 we must find the fisheries environment and the space for 2,450,000 fishermen in Colorado.

5. The Colorado Game and Fish Department is attempting to improve fishing conditions by an intensive lake and stream development program of its own.

During fiscal year 1960–61, the department is requesting $1 million out of a $4 million budget for the development of new fish environment through the improvement of streams and the construction of fishing lakes.

In the next 20 years, it is our feeling we will need to expend all of the funds which we may be able to obtain from the sale of fishing licenses, and, as much additional money as may be available from other sources to develop fisheries environment wherever it may be possible and wherever the water is available to meet this ever increasing demand.

In view of the above-discussed problems, the game and fish department therefore recommend:

1. First and foremost, that all water laws should recognize fish and wildlife values as a beneficial use of both flowing and impounded water.

2. Federal laws now being considered in which the Federal Government recognize State water laws should be enacted with a provision recognizing fish and wildlife as a beneficial use of water and provide for equal consideration with other uses in development projects in those instances where State laws are not specific or adequate.

3. Where the need for water is so great, as in the case of some domestic water projects, and possibly others, that the project

must be built and operated in a way that will damage fish and game values previously present, the sponsor of such a project should be required to mitigate and/or compensate for lost fish and game values.

4. Every effort should be made to find a satisfactory alternate plan for proposed water development projects which threaten the destruction of extremely valuable, unique, and irreplaceable fish and/or wildlife resources.

Thank you.

Senator CARROLL. Mr. Kimball, would you say that the Colorado Big Thompson project has great recreational value to the people of Colorado and to the tourists who come here.

Mr. KIMBALL. Yes, sir; I am willing to say that.

Senator CARROLL. It has enhanced fishing quite a bit; has it not?

Mr. KIMBALL. When you talk about fishing that is questionable, Senator. When you speak of recreation, if you are talking about boating, swimming, and water skiing and that aspect of it——

Senator CARROLL. They do fish up there. I do not know whether they catch any, but they do fish up there; do they not?

Mr. KIMBALL. That is right, they fish and the problem of quality fishing and whether they catch any, is the problem.

Senator CARROLL. If the Fryingpan-Arkansas was built and there was also a recreation area there, would that not help the fishing and wildlife of the State?

Mr. KIMBALL. In some aspects of that, Senator, it would be extremely detrimental. I am not familiar with the current plans, but in the previous construction project it called for diversion of the Arkansas River and putting the water through series of 6 or 7 power stations.

If you diverted the Arkansas River into a flume or into a power penstock leaving the river bottoms dry, then it would be extremely detrimental to fishing.

Senator CARROLL. You are not familiar with the recent plan?

Mr. KIMBALL. No.

Senator CARROLL. The new plan calls for a western slope up on the Frying Pan River where they will impound water and then that water, I have forgotten what the size of it—it would be a great recreational area besides impounding water for further beneficial use.

I observe here in your statement you would almost put fish and wildlife on equal bases with water for domestic and irrigation purposes.

Mr. KIMBALL. You note I say consideration of. Certainly we are not trying in all instances to put this value above others except to consider it.

There may be some instances where that may be the primary value. It should be considered, we feel, in connection with other uses.

Senator CARROLL. Thank you very much, Mr. Kimball, for your statement.

The CHAIRMAN. I would like to ask one question.

On page 1, you say:

This resource has made Colorado famous as a vacation area and plays a vital role in tourism which is Colorado's third largest industry—

et cetera; agriculture being your No. 1 industry?

Mr. KIMBALL. I believe it is either agriculture or manufacturing. They may have switched places here recently, but those are Nos. 1 and 2.

The CHAIRMAN. Nos. 1 and 2; thank you very much.

Senator CARROLL. Just one further question, Mr. Kimball:

Do you have any estimates on the visitor recreational values of reservoirs and streams?

Mr. KIMBALL. I know that they are very great.

Again, I would like to separate recreation values from that of fish and game because in the recreation visits you have these people who boat, who swim, who water ski, and that sort of thing, which is that value is not questioned in construction of these fluctuating reservoirs.

Senator CARROLL. I think you would have to consider, would you not, though, when you talk about this being our third important industry, that is tourism, that you would have to consider the impact of recreational values of reservoirs?

Mr. KIMBALL. Yes, sir.

Senator CARROLL. Recreation reservoirs and streams?

Mr. KIMBALL. Certainly they are a great attraction.

Senator CARROLL. All right. Thank you. Thank you very much, Mr. Kimball.

Mr. KIMBALL. Thank you.

Senator CARROLL. Mr. Sparks, will you come forward, please?

Mr. Chairman, Senator Martin, the next witness is our director of the Colorado Water Conservation Board, Mr. Felix L. Sparks, who, along with—I forgot to mention for the record—John Barnard. John, will you stand, please?

Mr. John Barnard is our first assistant attorney general in charge of water affairs, and he is also the past chairman of the Colorado Water Congress. He and Mr. Sparks have been largely responsible for the organization of the witnesses and the presentation of the testimony here this morning, and I wanted to pay my own tribute to Mr. Barnard.

I am sure the Governor and the rest join in with me and Senator Allott, and thank you for your fine work.

Mr. Chairman, as you spoke yesterday of our own Clifford Stone, who passed away——

The CHAIRMAN. Yes.

Senator CARROLL. Well, I knew Clifford Stone as a very fine man. As I recall, he was formerly appointed as director of the water board by Governor Ammon.

Now Mr. Sparks occupies the same position. He was appointed by Governor McNichols. He is a former member of the Supreme Court of Colorado and in my personal opinion, I think he is one of the best water lawyers in Colorado.

Mr. Sparks, we will be happy to hear from you, sir.

STATEMENT OF FELIX L. SPARKS, DIRECTOR, WATER CONSERVATION BOARD OF THE STATE OF COLORADO

Mr. SPARKS. Mr. Chairman and members of the committee, as Senator Carroll has stated, my name is Felix L. Sparks, and I am director of the Water Conservation Board of the State of Colorado.

I appear here today as a representative of that board.

It is the general purpose of the board to formulate and further a continuing State policy with respect to water development programs and problems, both intrastate and interstate.

Attached to this statement as table 1 is a condensed enumeration of the functions of the board.

(The table referred to follows:)

TABLE I. COLORADO WATER CONSERVATION BOARD

The following condensed enumeration of the functions of the board (created in 1937) and its composition was written by the late Judge Stone, the first director of the board.

"(1) To appraise and inventory the State's water resources and develop programs for their conservation, utilization and control.

"(2) To formulate and further a continuing State policy with respect to water development programs and problems, both intrastate and interstate.

"(3) To promote water projects and in connection therewith conduct investigations, make surveys and studies, and review and make official State comments upon project reports of Federal agencies.

"(4) To aid and callaborate with local affected interests and to consult with other interested State agencies and Federal agencies in all matters relating to the Federal water development program.

"(5) To handle interstate water relations and problems, including the furnishing of engineering service to the attorney general in interstate litigation over water; and to render aid and assistance, engineering and otherwise, to negotiating and administrative compact commissions.

"(6) And generally to aid in the conservation, beneficial utilization, development, and protection of the water resources of Colorado in the interest of the present and future welfare of the State and its citizens.

"The Colorado Water Conservation Board consists of 14 members. The Governor is an ex officio member and chairman. Other ex officio members are the attorney general, the State engineer, the director of the State planning commission, and the director of the Colorado Water Conservation Board. The remaining nine members are appointed by the Governor and serve for 3-year, staggered, terms. Four of these members are appointed from western Colorado, four from eastern Colorado, and one from the San Luis Valley, in the Upper Rio Grande Basin. Of the four members from western Colorado, one is appointed from the San Juan Basin, one from the Gunnison and Uncompahgre Basin, one from the main stem of the Colorado River, and one from the White-Yampa Basin area. Of the four appointed from eastern Colorado, one is appointed from the Arkansas Basin, one from the South Platte Basin, one from the North Platte Basin, and one from the city and county of Denver.

"In order to carry on its work the board maintains an engineering and legal staff. The executive officer of the board is the director, who is also responsible for representing the board and the State in various contacts with other States, with Federal agencies, and with water interests throughout the State. He is called upon to appear at various water hearings, including those conducted by committees of the Congress."

Mr. SPARKS. I wish to express the deep appreciation of the membership of our board for the committee's scheduling of this hearing in Colorado. We feel that a basic inventory of the Nation's water problems is long overdue, and we are delighted that the U.S. Senate has taken the initiative to create this factfinding committee.

We believe that it is highly appropriate that this committee should meet here in Colorado. In this State are found the headwaters of four of the major rivers of the West, the Platte, the Arkansas, the Rio Grande, and the Colorado.

These rivers are the life arteries of the State of Colorado. These rivers, or their tributaries, are of similar importance to the majority of the States west of the Mississippi River.

Geographically, Colorado occupies a unique position within the continental boundaries of the United States. Waters originating in other States are in nature not available for use in Colorado.

On the other hand, all of the surface waters of the State, excepting natural losses, are available by gravity to 18 other States. This, itself, would not be significant if it were not for the fact that by court decision and interstate compact we are compelled to deliver about 50 percent of our available surface water to other States.

This latter observation is not in the nature of a complaint, but is illustrative of how the water resources of a given State may be depleted without internal use.

The CHAIRMAN. Does your statement disclose the amount of water that flows out of Colorado annually?

Mr. SPARKS. It does not, Senator. We have those figures available and we would be glad to furnish them.

The CHAIRMAN. Fine.

Mr. SPARKS. In Colorado the use of water is governed by the appropriation doctrine. This doctrine is written into our constitution and statutes and has been generally adopted throughout the Western States.

I might add that this doctrine is commonly referred to as the Colorado doctrine.

As far back as 1900 the dependable natural flows of the Arkansas, Platte, and Rio Grande Rivers had largely been appropriated. Since that time millions of dollars have been expended in capturing floodflows, and millions more expended in transmountain diversions from the Colorado River.

The situation that we find ourselves in today is that we have already exhausted the surface water resources of three of our major river basins. Within the next 50 years the water resources of Colorado River Basin will have become almost entirely exhausted.

Our major problem today lies in developing our remaining water resources at a pace commensurate with our population increase. I am sure that this same statement has been made in every State in which this committee has visited.

Colorado's population is increasing at a rapid rate. According to the 1950 census, Colorado's population was 1,325,000. A projection of recent trends indicates a total population by 1980 of 2,600,000 for the State.

The CHAIRMAN. Have you an estimate of its present population?

Mr. SPARKS. We have that available, also. It is not included in here.

Senator CARROLL. What is the present population?

Mr. SPARKS. I was trying to recall. You can get at it here a little indirectly.

The CHAIRMAN. Forty thousand a year would be an increase of 400,000, about?

Mr. SPARKS. That is approximately correct. This means an annual net increase of about 40,000 persons. This population projection does not take into account the definite possibility of a major shale oil industry in western Colorado which could add another half million people to our population by 1980.

The most phenomenal growth in Colorado has occurred in the Denver metropolitan area, where 54.5-percent increase in population has taken place in the past 9 years.

The metropolitan counties of Arapahoe, Jefferson, and Adams have experienced a population increase of over a hundred percent in the past 9 years, with Adams County showing an astonishing 160-percent increase.

Water problems in Colorado are greatly compounded by the fact that the population distribution bears no relationship to the State's available surface water supply.

Attached hereto is table 2 showing the population distribution by river basin and the corresponding available surface water supply for that river basin.

TABLE II.—*Population and surface water production in Colorado's major river basins*

[In percentages]

River basin [1]	Percent of State population [2]	Percent of State surface water production [3]
South Platte	60	9.6
Arkansas	24	6.9
Rio Grande	3	9.3
Colorado	12	68.0

[1] North Platte and Kansas River Basins are omitted. Although these basins produce about 6.2 percent of the State's surface water, geography, interstate compact, and Supreme Court decisions permit only local and limited use in Colorado. These areas contain less than 1 percent of the State's population.
[2] Based on 1950 census.
[3] Estimated average annual.

You will note the tremendous disparity between the population and surface water production as shown by table 2. These figures are shown in percentages of the overall State total and do not reflect the depletions by virtue of interstate compacts and Supreme Court decisions.

In order to briefly summarize the water situation here in Colorado, I shall divide the State into it's four major river basins:

First, the South Platte River Basin:

The South Platte basin is the most heavily populated area of Colorado. In this basin are found Denver and its metropolitan area. Based on the 1950 census, the South Platte basin has about 60 percent of the State's population.

However, the estimated water production in the basin is slightly less than 10 percent of the State total.

The available water supply of the South Platte basin was long ago exhausted. The disparity between the population and water supply in this basin is much greater at the present time and will continue to increase, since the State's greatest population growth during the past 9 years has occurred in this area.

The population of the South Platte Valley has increased roughly by 300 percent during the past 30 years. New water supplies have been developed by transmountain diversions from the Colorado River.

However, there is a limit to the availability of the Colorado River waters and the utmost conservation measures must be utilized in the basin if future growth is to be insured.

In the near future approximately 500,000 acre-feet of water annually will be exported into the South Platte basin from the Colorado River Basin from two systems alone, the Denver municipal water supply system and the Colorado-Big Thompson has to date been the major reclamation project in the State of Colorado with a total cost of approximately $159 million.

The privately financed Denver municipal water supply expansion to divert waters of the Colorado River, now under construction and partially completed, will cost together with its power features, an estimated $183 million.

Several important projects which would capture the small remaining amount of floodwaters and permit greater river regulation are now in the planning stage and in all probability will be constructed prior to 1980.

The principal project in this category is the Narrows project on the South Platte River near the city of Fort Morgan, which has already been authorized by Congress.

Projected expenditures for the South Platte Basin for water resource development through 1980 is estimated at $413,852,000. This amount can be broken down into expenditures of $232,125,000 from non-Federal funds and $181,727,000 from Federal funds.

The CHAIRMAN. May I interrupt?

Mr. SPARKS. Yes, Senator.

The CHAIRMAN. You say the Denver municipal water supply in the Colorado-Big Thompson projects will divert 500,000 acre-feet annually?

Mr. SPARKS. That is correct.

The CHAIRMAN. Divided between the two in what proportion?

Mr. SPARKS. It is almost equal.

The CHAIRMAN. In other words, the Big Thompson project brings about half of that amount now?

Mr. SPARKS. That is correct; on the average.

The CHAIRMAN. And how much lift is there of that water as it is brought from the west to the east slope?

Mr. SPARKS. There is not a great lift. The principal lift occurs in the western slope system and transferring waters back and forth between the Grand Reservoir and the Shadow Mountain and the Willow Creek Reservoirs.

It is relatively small amount of lift, however. For the most part the system is a gravity system.

The CHAIRMAN. The principal use of that water on this side of the divide is what?

Mr. SPARKS. The principal use is irrigational, although it has some municipal function, also.

The CHAIRMAN. Wholly committed?

Mr. SPARKS. Wholly committed.

The CHAIRMAN. Thank you.

Mr. SPARKS. The Arkansas River Basin in southeastern Colorado occupies second place in population total. In this basin are found two of Colorado's major cities, Pueblo and Colorado Springs.

As is true of the South Platte Basin, industrial and commercial activities greatly exceed agricultural production. The Arkansas Ba-

sin contains about 24 percent of the State's population, but only about 7 percent of the State's surface water supply.

A significant portion of the flow of the Arkansas River must be shared with the State of Kansas.

Any appreciable population growth in the future will not be possible in the Arkansas Valley unless additional water resources are made available.

One of the State's major reclamation projects, the Fryingpan-Arkansas, has long been planned to augment the already exhausted water supply of this area. This vital project is now awaiting congressional authorization.

The CHAIRMAN. Would you give me the details of the Fryingpan project?

Mr. SPARKS. Senator, the Fryingpan project involves the average annual exportation of water from the Fryingpan River, which is a tributary of the Colorado. This average amount would be 69,200 acre-feet of water annually. In addition to the exportation there would be storage of approximately 100,000 acre-feet in the Ruedi Reservoir, which would act as a replacement and also provide a great amount of water for use in western Colorado. In other words, this project is essentially a State project and involves both sides of the Continental Divide.

The CHAIRMAN. Would it mean the taking of water from one tributary of the Colorado and moving it to the Arkansas River, essentially, and then the waters of the tributary of the Arkansas, and moving it into the Colorado system?

Mr. SPARKS. No. It would involve, purely as far as the Arkansas is concerned, a diversion from the Colorado River into the Arkansas River Basin.

The waters of the Fryingpan, by court degree and by stipulation and agreement in the State of Colorado, would be divided between the transmountain project and between storage in western Colorado.

In other words, 69,200 feet of that water—acre-feet—would be transported into the Arkansas Basin. The remaining flow of the Fryingpan would be captured and retained in the Ruedi Reservoir for use in western Colorado.

The CHAIRMAN. Or to provide more normal flow and steady supply?

Mr. SPARKS. That is correct. It would primarily capture the flood-flows which now go to waste.

The CHAIRMAN. Thank you.

Mr. SPARKS. This project has both municipal and irrigation and hydroelectric features.

The CHAIRMAN. Yes.

Senator CARROLL. May I interrupt at this time?

Mr. SPARKS. Yes.

Senator CARROLL. Did you hear the testimony of Mr. Kimball? Were you present here when Mr. Kimball testified, Mr. Sparks?

I asked the question about the proposed Ruedi Reservoir, the Fryingpan. That has now been changed, has it not?

Mr. SPARKS. That is correct. And the Bureau of Sport Fisheries and Wildlife has assigned benefits to the project as the result of better stream regulation to Fryingpan River and because of the impoundment in Ruedi Reservoir.

Without question we always encounter difficulties in working out all phases of these projects. But certainly every agency of the Federal and State Government is becoming increasingly aware of the need for integrating recreational and fish and wildlife features into our various projects.

We are doing that without exception in every project now under contemplation.

Senator CARROLL. Would you say that Lake Granby and Shadow Mountain of the Colorado-Big Thompson have been a great benefit to the people and to the tourists?

Mr. SPARKS. I can say without exaggeration that that area has attracted in its present state at least 50 people for every 1 that it attracted before the project was constructed.

Senator CARROLL. And is this sort of recreational area contemplated in the Fryingpan-Arkansas?

Mr. SPARKS. Such a recreational area is contemplated and will be an integral part of the Fryingpan-Arkansas project; yes.

No Federal reclamation project has yet been constructed for the benefit of the Arkansas Valley, although the John Martin Reservoir, constructed by the Corps of Engineers, has contributed greatly to the economy of the area.

As is common with the South Platte Valley, rigid conservation measures must be undertaken for the maximum utilization of the available water supplies.

The Trinidad project, primarily for flood control, has been authorized for construction in the Arkansas Valley. This project will have a small amount of conservation storage.

Anticipated expenditures for water resource development in the Arkansas Valley through 1980 are estimated at $202,682,000. Of this amount, $194,269,000 is estimated as Federal expenditure and the remaining $8,413,000 as non Federal expenditures.

In south-central Colorado is found the San Luis Valley traversed by the Rio Grande River. Relatively isolated by the Continental Divide on the west and the Sangre de Cristo Range on the east, the San Luis Valley contains about 3 percent of the State's population and approximately 9 percent of the total surface water supply.

However, under the terms of the Rio Grande compact, New Mexico and Texas make heavy demands on the Rio Grande River. Because of these demands, there is a chronic shortage of available water in the valley. The economy of the valley is heavily agricultural and fluctuates in direct proportion to the annual precipitation. The valley itself is one of the most arid areas in Colorado and the average precipitation at Alamosa, the principal city, is only about 5 inches annually. There is little opportunity to increase the water supply of the area except from the application of conservation measures.

Promising water salvage investigations are now being currently conducted by the Bureau of Reclamation. I might add that the cost of these projects or the investigations are being shared by the State of Colorado.

The specialized agricultural and livestock production of the San Luis Valley contributes greatly to the overall economy of the State.

Project expenditures for water resource development in the Rio Grande Basin through 1980 are estimated at $32,957,100. Of this

amount, $32,380,000 is classified as a Federal expenditure and $577,100 as a non-Federal expenditure.

The Colorado River drains all of that portion of the State of Colorado lying west of the Continental Divide. This is Colorado's major river and is one of the major rivers in western United States.

The Colorado River produces about 68 percent of the State's total water supply, but only about 35 percent of this amount is available for use in Colorado. The river produces on the average, in Colorado, about 11 million acre-feet of water annually.

Under the terms of the Colorado River compact and the Upper Colorado River compact about 3,900,000 acre-feet annually can be used in Colorado.

Western Colorado has an abundance of natural resources and a major livestock and agricultural economy. It contains about 12 percent of the State's population. The potential industrial development of this area, however, is of great magnitude. Locked in the shale deposits of the Colorado River Basin are oil reserves estimated to be several times greater than the petroleum reserves of the entire world.

During the past 15 years about $50 million has been spent in shale oil development. Economical mining and restoring processes have now been developed, and careful study indicates commercial shale oil production may be underway by 1965. At least 250,000 acre-feet of water annually must be reserved for this potential industry and allied municipal growth.

The CHAIRMAN. I wonder if I may interrupt just a moment.

I have been trying to learn the amount of water produced in Colorado and which flows out of the State and I believe that the answer to that question is in the paragraph you have just read.

Your statement is that the Colorado River produces about 68 percent of the total water supply of the State?

Mr. SPARKS. That is correct.

The CHAIRMAN. And that that amounts to about 11 million acre-feet?

Mr. SPARKS. That is produced in the Colorado River.

The CHAIRMAN. That amount is about 68 percent of the total produced in the State?

Mr. SPARKS. That is correct.

The CHAIRMAN. That, then, would indicate that some 15½ or 16 million acre-feet is the total amount of water produced in the State?

Mr. SPARKS. That is correct.

The CHAIRMAN. And that, of that amount, the State reserves and uses about what?

Mr. SPARKS. About half of it.

The CHAIRMAN. About half of it. But that use does not consume half of it?

Mr. SPARKS. Not at the present time. But we will have the right to consume half of it.

The CHAIRMAN. In other words, you will have the right to consume the water to the point that the amount leaving the State will be approximately 8 million acre-feet?

Mr. SPARKS. That is correct.

The CHAIRMAN. Thank you very much.

Mr. SPARKS. Colorado's greatest activity in water resources development through 1980 and thereafter will occur in the Colorado River Basin. Currently, two reclamation projects are under construction in western Colorado and money has been appropriated for the Keystone project. The Curecanti, on the Gunnison River, is awaiting a congressional appropriation for construction.

The total expenditures for water resource development in the Colorado River Basin in Colorado through 1980 are estimated at $651,044,000, of which $633,109,000 is classified as Federal investment and $17,935,000 from local sources.

We have attempted here to give only a very brief picture of the river basins of this State. Other presentations before this committee today will cover in greater detail the water resource problems of each of the river basins.

Senator CARROLL. May I interrupt at this time, Mr. Sparks?

We have discussed the Ruedi Reservoir and its recreational benefits. I assume the Curecanti project also will have a recreational value, will it not?

Mr. SPARKS. Curecanti will have a tremendous recreational value.

Senator CARROLL. Have the recreational values been computed for this project?

Mr. SPARKS. They have been computed. Over $3 million of the project cost has been allocated for recreational development.

Senator CARROLL. In which project?

Mr. SPARKS. In the Curecanti project.

Senator CARROLL. In the Curecanti?

Mr. SPARKS. Another $3 million will be required by private concessionaires to bring the recreation area to acceptable standards.

In other words, over $6 million will go into the recreational areas of the Curecanti project.

Senator CARROLL. You may proceed, thank you, sir.

Mr. SPARKS. It will also be the largest reservoir in the State of Colorado and one of the most scenic, we think, in the world.

Senator CARROLL. Just one other question occurs to me.

Mr. Chairman, this is probably a problem that may come up later on. It is the matter of computing the interest formula on Federal projects. In the Colorado River Storage Act we have one formula, in other acts we have a different formula.

Unless we change the interest formula in the Curecanti project it may materially affect its economic feasibility.

Do you care to make a short comment on that, Mr. Sparks?

Mr. SPARKS. Well, the interest rate which was assigned to Public Law 485 was distinctive and as far as we know no other project in the history of the United States has had a similar interest rate.

As a result, unexpected fluctuations have occurred in that interest rate which, of course, jeopardize every project under the storage project act.

Senator CARROLL. Let's put the question a little differently:

If we now had to construct a Colorado-Big Thompson under existing law wouldn't it have affected it economic feasibility?

Mr. SPARKS. It definitely would have, yes. Not the existing law particularly, Senator, but the existing law that pertains to the Colorado River storage project act.

Senator CARROLL. That is what I had in mind.

Mr. SPARKS. I know, Senator Kerr is extremely familiar with that. As I noted in the Norman bill the interest formula is not the same as the storage project act.

The CHAIRMAN. You see the interest rate in the Norman bill is the rate which is prescribed for such projects, by title 3 of the 1958 flood control act of which the Senator from Oklahoma was a joint author.

I want to say as far as he is concerned, it will be the interest rate applied to the—what do you call it, the Upper Colorado?

Mr. SPARKS. Colorado River storage project.

The CHAIRMAN. Yes, sir.

Mr. SPARKS. We will be very grateful for that attention, Senator.

The CHAIRMAN. Here is the thing about it: I do not want to trigger a discussion of something else, but one of the monstrosities of this century is the present interest rate structure and I am convinced that it is a passing thing and therefore should not be something that will be saddled on the areas that are compelled to reimburse the Federal Government substantial parts of the cost of these necessary water conservation projects.

Mr. SPARKS. That is a very welcome statement to Colorado, I can assure you.

Senator CARROLL. I want to say to the Senator from Oklahoma that I was on the Interior Committee when the Norman project came up and with Senator Anderson of New Mexico, we discussed this question of the interest rate and we did devise as I recall, what I conceived to be the proper formula for the Norman project and if we do not get that Curecanti, it may seriously affect its economic feasibility.

The CHAIRMAN. The amendment to the law authorizing the Norman project passed the Senate and carried an amendment making the same interest rate applicable to your project.

I say frankly that it is my hope that the amendment will be kept in the bill both through the House and as it may be signed by the President.

Senator CARROLL. Go ahead, Mr. Sparks.

Mr. SPARKS. As can be readily perceived, there has been in the past and will continue to be in the future, great competition among various users in various sections of the State, over the remaining water resources. We are already faced with the necessity for better conservation practices. Such practices can be developed only after patient and exhaustive basic research.

The total expenditure for water resource development in this State projected through 1980 is estimated at $1,300,535,100. Of this amount $1,041,485,000 is classified as a Federal expenditure, and $259,050,100 as non-Federal.

The CHAIRMAN. I want to thank you for putting that in because I have been sitting here going through your statement trying to figure up just what those totals are.

Now, I find you supplied that with your manifest attention to important details.

Mr. SPARKS. This total expenditure is summarized by purpose and river basin in the attached table III. These figures do not include any expenditures for the development of ground water.

This table, gentlemen, we have tried to break down. In some way it will be helpful to you. We have shown the various categories of expenditures by both Federal and State agencies.

The CHAIRMAN. I must say that I get a different total than you do. Are you talking about what will be spent and that does not include what has been spent.

Mr. SPARKS. That does not include what has been spent.

The CHAIRMAN. Fine. Thank you.

Mr. SPARKS. Table IV shows the amount of money which has been expended by Federal agencies for completed projects which is a total of $222 million.

We have included this table merely for means of comparison. This table does not include expenditures by the Soil Conservation Service.

The CHAIRMAN. You say this does not include the expenditures, either past or future, by the Department of Agriculture.

Mr. SPARKS. It does not because, actually, those expenditures have been fairly recent and as of yet we have no fully completed projects, although some major projects are practically completed.

(The tables referred to follow:)

TABLE III.—*Estimated expenditures for water resource development in Colorado, 1954–80*

	Irrigation	Municipal and industrial	Flood control	Fish and wildlife and recreation	Hydroelectric power	Total
Platte River Basin:						
Federal	$71,487,000	$9,200,000	$22,931,000	$609,000	$77,500,000	$181,727,000
Non-Federal	513,000	[1] 184,454,000	4,935,000	223,000	42,000,000	232,125,000
Total	72,000,000	193,654,000	27,866,000	832,000	119,500,000	413,852,000
Arkansas River Basin:						
Federal	82,336,000	34,200,000	29,327,000	1,906,000	46,500,000	194,269,000
Non-Federal	1,345,000	(1)	7,068,000			8,413,000
Total	83,681,000	34,200,000	36,395,000	1,906,000	46,500,000	202,682,000
Rio Grande River Basin:						
Federal	19,580,000		12,300,000	500,000		32,380,000
Non-Federal	286,100		150,000	141,000		577,100
Total	19,866,100		12,450,000	641,000		32,957,100
Colorado River Basin:						
Federal	465,493,000	2,500,000	1,272,000	5,702,000	158,142,000	633,109,000
Non-Federal	2,868,000	10,036,000	2,758,000	2,273,000		17,935,000
Total	468,361,000	12,536,000	4,030,000	7,975,000	158,142,000	651,044,000
State total recapitulation:						
Federal	638,896,000	45,900,000	65,830,000	8,717,000	282,142,000	1,041,485,000
Non-Federal	5,012,100	194,490,000	14,911,000	2,637,000	42,000,000	259,050,100
Total	643,908,100	240,390,000	80,741,000	11,354,000	324,142,000	1,300,535,100

[1] $33,000,000 in this category shown in the Platte Basin is actually a joint enterprise between the Platte and Arkansas River Basins.

TABLE IV.—*Completed Federal projects in Colorado*

BUREAU OF RECLAMATION [1]

Project	Date	Cost
Uncompahgre	1904	$11,922,797
Grand Valley	1912	8,688,602
Pine River	1938	3,444,294
Fruitgrowers	1938	200,309
Colorado-Big Thompson	1938	159,385,440
Mancos	1941	3,949,840
Platoro	1949	3,837,415
Total, Bureau of Reclamation		191,428,697
CORPS OF ENGINEERS		
John Martin	1940	$15,070,000
Cherry Creek	1946	14,600,000
Templeton Gap	1948	888,900
Creede Willow Creek	1949	162,089
Pueblo	1952	217,500
Aurora	1952	150,000
Total, Corps of Engineers		31,088,489
Grand total, both agencies		222,517,186

[1] Bonney Reservoir constructed in eastern Colorado not shown since benefits are largely in Kansas.

The CHAIRMAN. Have there been estimates of what that might be?

Mr. SPARKS. They are included in a projection through 1980.

The CHAIRMAN. In the figure which you have already given?

Mr. SPARKS. That is correct, but they are not included in the past expenditures.

The CHAIRMAN. Yes.

Mr. SPARKS. From this thumbnail sketch of the surface water resources of the State of Colorado, we now refer to more specific topics.

Water users in Colorado can be classified in three general catagories, to wit:

Agricultural, municipal, industrial, and recreational.

Recreational uses, until recent years, have largely been incident to the other uses. However, recreation associated with Colorado's streams and lakes has now become a major industry and must be regarded as an integral part of all water resorce development.

Since water supplies are limited, tremendous competition has developed among the various uses. At the present time a significant portion of municipal and industrial water supplies were formely used for irrigation.

The basic economy of Colorado has changed successively from mining to agriculture, and from agriculture to industry.

Demand for all uses will continue to increase.

Simple economics at this time indicate that municipal and industrial uses are in the most competitive position.

It has not been possible to adopt any fixed policy in this State with reference to the various competing uses.

Increased attention, however, is being given to the planning of future water supplies for municipal and industrial purposes.

At the same time we must bear in mind that in future years our present agricultural production will not be sufficient to feed and clothe the rapidly multiplying human population. Recreational uses, regardless of their desirability, will be primarily incidental to other uses.

Until recent years water quality had not been a general problem to the State of Colorado. Today, however, the widespread use of detergents, municipal and industrial wastes, together with the diminution of streamflow, are creating serious water quality problems. These problems become aggravated with the passage of each year.

The basic change from an agricultural to an industrial economy is now being reflected in both surface and ground water supplies.

During the past 2 years the residents of northwestern New Mexico have become alarmed over radioactive wastes discharged into the San Juan River from milling activities in Colorado.

Remedial action is now being undertaken by the milling companies to eliminate the contamination, but it should never have occurred in the first instance.

In recent weeks all of Colorado has been aroused to learn that toxic wastes from the U.S. Arsenal near Denver have seriously contaminated the ground water supplies of that area. The tragedy of this contamination lies in the fact that even assuming that the contaminating source has been, or will be, removed, there is no known method of purifying the contaminated ground water supply.

It may be that the ground water aquifer in that area will be contaminated for a period of from 5 to 15 years. This type of contamination again is inexcusable.

To date, water quality control and inspection has been a neglected stepchild to water resource development and planning.

Senator CARROLL. May I interrupt there?

As I explained to the chairman, Senator Kerr of Oklahoma, and Senator Martin of Iowa, on our way in from the airport, I explained partially the situation existing at the Rocky Mountain Arsenal northeast of Denver. Pollution of the underground water supply has occurred from some activities of the Federal Government, the military establishment, and, I believe, in part from some of the chemical companies who are lessees of the Federal Government.

As Mr. Sparks indicated, there has been considerable investigation, which is going on at this very time, by the Public Health Service, the U.S. Geological Survey, and by the Corps of Engineers, to meet this very sad and tragic situation affecting farmlands and well water. They have not come up with a definite answer yet, but there is some real liability on the part of the Government. Congressman Byron Johnson of the second district has been a leader in this investigation.

He has been conferring with the Governor of Colorado and, of course, has been in very close touch with my office on the situation.

We are helping in every way possible. I do not know whether this committee has met this contamination and pollution in other areas, but it is quite serious in and around Denver.

It may move in and we hope it does not, it may move into one of our principal cities just outside of Denver.

As Mr. Sparks has indicated——

Senator MARTIN. I was interested in your statement there yesterday, Senator Carroll. I was curious about how wide an area is now contaminated and what the possibility of still further expansion of that contamination was?

Senator CARROLL. Mr. Sparks, I think, has been following this very closely. Will you discuss that very briefly, the area and some of the immediate problems and what you think we can do about it?

Mr. SPARKS. The contamination of course, will spread. As the ground water travels extremely slowly, perhaps at the rate of less than a mile a year, considerably less than that in some cases, so the contamination will continue to spread in an area and as I have stated there is no known method of doing anything about that contamination. It is a water resource which once ruined becomes irrevocably ruined for a good many years to come until nature eventually flushes it out.

Senator MARTIN. Does that kill off plantlife?

Mr. SPARKS. That toxic waste there does kill off plant life.

Senator CARROLL. One of the problems, as we have observed very often in the Senate and House, is the secrecy that is thrown around a military project. Sometimes this is to the detriment of the public. In this case we should have had information on the pollution some years ago and we could have acted to prevent it.

As I understand it at one time they were confronted with the Arsenal projects as being secret military operations. Now reports on the cause of the pollution are finally coming out.

They could have disclosed this information years ago and we could have stopped some of this pollution and contamination.

Mr. SPARKS. At the present time only the State and Federal health agencies have made active attempts to prevent the contamination of water supplies. These agencies have had little or no help from other agencies of the State and Federal Governments in preventing the contamination before it occurs.

We have long neglected this important water quality problem in our State planning and have made little use of the services offered by the Water Quality Branch of the U.S. Geological Survey.

I am sure that the people of this State involved with water resources give the highest priority to water quality inspection and control.

The Federal Government can be of great assistance in this field, but, like our own State agencies, the agencies of the Federal Government are poorly coordinated in achieving the maximum prevention and control of water pollution.

As already pointed out, the natural surface water supplies of the three of our major river basins in Colorado are already largely exhausted.

However, the ability of the human race to propagate has not become exhausted. Consequently the same water supply which may seem insufficient for 100,000 people today, may have to suffice for a million people in the future.

Better utilization, salvage, and reuse of water are the only ultimate answers.

In the San Luis Valley, in cooperation with the Bureau of Reclamation, we have under study various methods of salvaging water going to waste. The cost of this program is being shared equally between the State and the Federal Government.

Similar projects are in the planning stage for the Arkansas and South Platte River Valleys.

Basic research in water utilization and production has long been one of the most neglected fields of scientific endeavor. Research

activities of both State and Federal agencies has had no real impetus nor ultimate goal.

You have already heard, or will hear today, from two of our State universities on the subject of research. We have on the technical staff of our water conservation board persons who are experts in the field of water resource development. These people are of the unanimous opinion that they are seriously handicapped in the performance of their work because of the lack of basic research on water problems.

I shall not dwell upon the various fields of research activities since this subject will be presented to you by Dr. Morgan of Colorado State University, and Dr. Roberts of the University of Colorado.

The Federal Government has played a vital part in the development of the water resources of the State of Colorado. Its agencies have been indispensable to the welfare of this State and to every other State of this Union and will continue to be so.

The particular agencies involved in the development of our water resources are the Bureau of Reclamation, U.S. Geological Survey, the Corps of Engineers, and the Soil Conservation Service.

One of the oldest reclamation projects in the United States was begun in Colorado in 1904. Since that time reclamation development has been rather slow in Colorado, but with the passage of the Colorado River Storage Project Act in 1956, reclamation activity in Colorado has reached a new height of activity.

Since the construction of the Colorado-Big Thompson our Weld County, north of Denver, has become one of the leading counties in the Nation in the value of agricultural production.

It is no mere coincidence that the four most populous counties in western Colorado are also areas of reclamation development. Our relationship with the Bureau of Reclamation has been, on the whole, most cordial.

For several years past our Colorado General Assembly has been appropriating the sum of $100,000 annually to be expanded under cooperative agreements with the Bureau of Reclamation.

In addition to this expenditure, the engineering and legal staff of our water conservation board often work jointly with Bureau personnel on various studies and investigations.

We would very much like to cooperate with the Bureau of Reclamation in basic research activities, but funds appropriated to that organization for such purposes have been negligible.

An agency which does not receive its proportionate share of credit in the development of this Nation's water resources is the U.S. Geological Survey. This important agency has been responsible for recording and disseminating the water supply data upon which all of our projects are based.

The State of Colorado is now expending over $30,000 annually in a cooperative program with the U.S. Geological Survey in obtaining and recording basic streamflow data.

The general assembly is now appropriating the sum of $75,000 annually for a cooperative survey of our ground-water resources.

In the future we expect to enter into cooperative agreements with the water quality branch of that agency.

Senator CARROLL. May I interrupt at this point to say to Senator Martin and Senator Kerr that the State of Colorado under the leadership of Governor McNichols, has been moving ahead, appropriating

money and cooperating with the Bureau of Reclamation and the U.S. Geological Survey. We in the Senate have been doing our part also. We appropriated for research by the Bureau of Reclamation $250,000. However, this was cut to $70,000 by the House in conference and that is all the money that was finally given.

There is a great need for additional basic research funds for the Bureau of Reclamation and the U.S. Geological Survey, not a great amount of money, but enough to take care of this tremendously important work. I hope that we can call this to the attention of the appropriate committee of the Senate and we would like to have the support of the members of this present committee.

You may proceed, Mr. Sparks.

Mr. SPARKS. Two major projects have been constructed in the State of Colorado by the Corps of Engineers, and the Trinidad project on the Purgatoire River was recently authorized by Congress.

The corps plays an important part in determining flood control benefits or projects constructed by other Federal agencies.

There still remains considerable flood control work to be done in Colorado, although a major portion of the problem will be solved by the flood control capacity of Bureau of Reclamation projects.

The flood problem in the Denver metropolitan area has become aggravated in the past few years as a result of poorly supervised subdivision planning and construction.

There is often a tendency to lose sight of the work of the Soil Conservation Service because of the magnitude of projects constructed by other Federal agencies. Nevertheless, the work of this agency is becoming of increasing importance to the State of Colorado.

Senator CARROLL. May I interrupt here to go back to the Purgatoire? What is the progress and development there at the present time?

Mr. SPARKS. At the present time a definite plan report is in the process of preparation. We are, in other words, in the final stages of getting the project ready for construction.

Senator CARROLL. Do you have any idea about when construction could start?

Mr. SPARKS. That could start probably next year, if we had the money, Senator Carroll.

Senator CARROLL. If you had the money. In other words, the money appropriated has been for planning and survey?

Mr. SPARKS. No money has been appropriated for construction. Several important projects planned by the Soil Conservation Service are now under construction or nearing completion on our eastern plains. The accumulative effects of these small projects constructed at strategic locations, is often more beneficial than a single project of great magnitude.

The Colorado office of that agency is understaffed and is being supplemented by a planning party from the staff of our State water conservation board.

Soil and moisture conditions are a primary investigative function of the Soil Conservation Service. The proposed high plains soil and moisture laboratory is of tremendous interest to the Colorado Association of Soil Conservation Districts.

Mr. Clarence A. Foster, of Colorado Springs, State president of this association, has requested that I convey the association's endorsement of such a laboratory.

The establishment of this laboratory is also strongly urged by our board, since it would accomplish vitally needed research on soil and moisture conditions.

This statement has heretofore been primarily limited to the surface water resources of this State. However, we do not wish to convey the impression that we are entirely dependent upon surface water supplies.

In the Rio Grande River drainage in Colorado, extensive use has long been made of ground-water resources. Both the Arkansas and Platte River Valleys contain important ground water aquifiers.

The use of these resources is rapidly increasing to the point that there is considerable suspicion that it is interfering with surface water supplies.

Experience has already shown us that ground water supplies can be rapidly depleted. We have been reluctant, to date, to grapple with the problem.

At the present time we have no specific law which regulates the use of ground water. Ground water, because of its elusive nature, has not been readily susceptible to workable controls.

As has already been mentioned, we are cooperating with the U.S. Geological Survey to the extent of $75,000 per year, to determine the extent and character of our ground water resources.

We anticipate that this statewide survey will be completed within the next 10 years. This survey is only a partial solution to the ground water problems. Much work must be done to determine the relationship between ground and surface waters.

Senator CARROLL. Mr. Sparks, I learned the other day that the Corps of Engineers is contemplating sinking a deep well some 10,000 feet to put sludge in from this contaminated, this polluted area. Is there any indication of what that may do at 10,000 feet? Do we know what the waters are at that level?

Mr. SPARKS. I don't think we know anything about them at that level, Senator. At that level in this area there are certainly no wells which even approach that depth.

As a matter of fact, under present economics it would not be economically feasible to pump water from that depth. So it may be a solution to some contamination problems.

But I would certainly not state, however, that it would not interfere with ground water resources at some point in the United States.

Senator CARROLL. I was wondering whether or not there could be some underground movement of water at great depths which may contaminate an area of a much wider area.

Mr. SPARKS. Of course, there is definite movement of ground water at that depth.

Senator CARROLL. We will discuss that later. Thank you very much.

Mr. SPARKS. I am sure that this committee has already come to the conclusion that there is a remarkable similarity among the water prolems of the various States. It is a rare instance in which there is no interstate competition over a common source of water supply.

Pollution and flood control problems have no respect for the State boundaries.

The U.S. Supreme Court has repeatedly held that no State has exclusive jurisdiction over waters originating within State boundaries. We are in accord with this principle as long as it is confined to factual situations involving interstate compacts and relations.

What we are observing here is that water problems are of national scope and, therefore, a legitimate and necessary field of activity for the Federal Government.

Throughout this presentation we have referred to the exhaustion of water supplies in the various basins of this State. We did not mean to imply that such water supplies have been exhausted to the extent of maximum possible utilization.

The term was used to denote exhaustion under our present methods of use. Probably no natural resource has been, or is being, subjected to such extravagant waste as our water resources.

Fortunately, man's activities do not destroy the basic characteristics of water. It is obvious, however, that the only ultimate answer to the water problem lies in the maximum use and reuse of the waters that are made available to us by nature.

Basic research to promote this maximum use has been feeble and almost completely uncoordinated.

Only by entering actively into this field of endeavor can the Federal and State Governments discharge their responsibilities to the people of this country.

Thank you.

Senator CARROLL. Mr. Sparks, I want to thank you for a very, very excellent statement. It would be fine if all the people of Colorado who are concerned with water could read this excellent statement.

I not only thank you for the expression, but for your great help in planning this hearing this morning along with John Barnard.

Are there any further questions of Mr. Sparks?

Thank you.

The next witness will be Mr. Petry or Mr. Saunders, of the city and county of Denver.

I understand, Mr. Chairman, that Mr. Saunders, who is the attorney for the Board of Water Commissioners of the City and County of Denver, is going to testify on municipal water problems for all Colorado cities, and accompanying him is Mr. Petry, who has been for 12 years on the Denver Board of Water Commissioners, a man of great experience, and after the conclusion of Mr. Saunder's testimony, if we desire to put any questions to Mr. Petry, he is available.

Have I correctly stated the situation?

STATEMENT OF GLENN G. SAUNDERS, MEMBER, AND CHIEF COUNSEL, OF THE DENVER BOARD OF WATER COMMISSIONERS

Mr. SAUNDERS. I could modify it just a little. Mr. Petry found himself in the position where he had people from outside the city who were depending upon him for some work and he is in here and listening to this discussion, but he is going to be forced to leave because these people have limited time here, too.

I will be, therefore, the one who will answer any questions that the Senators may have.

Senator CARROLL. May I say, Mr. Chairman, to the committee, that Mr. Saunders is a distinguished lawyer and member of the Denver Bar, Colorado Bar, and has been in water ligitation and advising and counseling in municipal water problems for many, many years.

Mr. Saunders, will you proceed, please?

Mr. SAUNDERS. Thank you.

In addition to Mr. Petry, there are present here to assist the committee in any way they can, Mr. Bob Peterson, who is the sanitary engineer for the city and county of Denver.

Mr. Charles Fisk, the water supply engineer of the Denver Water Department, and also the man who will be here throughout the hearing.

Mr. Don Hamburg, who is at your service for any purpose that you may wish.

Mr. Robert S. Millar, of the water department is also present as is John Patterson of our water supply division.

Senator CARROLL. You may proceed, Mr. Saunders.

Mr. SAUNDERS. It is true that this matter, as we will present it, does have to do with the cities of Colorado and yet we are going to reflect the Denver view pretty much because if we have the Denver picture we pretty well have the urban picture of Colorado.

The CHAIRMAN. You think what is good for Denver is good for Colorado?

Mr. SAUNDERS. What is good for Colorado is good for Denver, too.

The CHAIRMAN. All right.

Mr. SAUNDERS. This paper has been gone over by the city attorney of Colorado Springs, because of the limitation of time we were unable to go over this with officials of other cities.

This statement was prepared for joint presentation by Mr. Petry and myself.

We being, respectively, a member of the water commissioners, and the chief counsel.

The Denver system is owned by the people of Denver and operated by a nonpolitical board of five members appointed by the mayor for staggered 6-year terms.

The Denver Water Board, through a staff of approximately 600 employees, is charged with the responsibility of supplying all water used by most of the Denver metropolitan area, both inside and outside the boundaries of the city.

For the sake of brevity, and because of our close cooperation with the city administration, the mayor of Denver has asked me to speak for him on that phase of the water resource problem, which has to do with purification for further use of the waters of the city.

However, it should be understood that the responsibility of providing adequate sewage treatment lies with the general government of the city of Denver, and not with its Board of Water Commissioners.

In Colorado nature never allows man to long forget that water is as important to his continued existence as air, but that unlike air, it is not free and not constantly available.

Moisture in the form of perpetual snow is abundant at the top of the high peaks which form the Continental Divide between the Atlantic watershed and the Pacific watershed. But the use of this moisture on the plains below presents problems of serious magnitude.

In the plains area of Colorado, the scant rainfall occurs in such a sporadic pattern and so unpredictably as to the time and extent of its coming, that only by his most careful ingenuity in using the available water can man create a civilization.

But with his usual capacity for adapting his life to the challenges of nature, man is carving a highly developed civilization in Colorado, founding it on an intricate, but reliable water development program.

Denver, not only the political capital of Colorado, but also the capital of a growing scientific and cultural center, bases its vigor and growth on its own well-planned water system designed and constantly under construction to meet the needs of its explosive population demands.

What does the term explosive population mean to Denver?

It means that we visualize that there is nothing, aside from the adequate water supply, to prevent the entire front range of the Colorado Rockies from Fort Collins to Pueblo from eventually becoming a vast metropolitan complex.

What is said here of Denver's many water problems applies in varying degrees to numerous other cities in Colorado, each with its own special problems. We can refer most often to Denver because the declineation of its problems will form an encyclopedia of most of the problems of other cities in Colorado.

We may also properly refer to Denver principally as the example of the urban water problem in Colorado because the Denver Water Board serves approximately 40 percent of all the people in Colorado.

The CHAIRMAN. What is your metropolitan population, Mr. Saunders?

Mr. SAUNDERS. The metropolitan population is around 800,000 and of that, we serve only 670,000 of the people.

It is constantly growing. We believe that at this time we are growing at the rate of a little better than 3,000 a month.

We should also note that this is outside of the Colorado Springs and Pueblo area. Pueblo is a separate area in itself and Colorado Springs lying somewhere midway between the two, has its own special problems and they are growing rapidly.

Denver's industries are of considerable importance to Colorado. For example, the sixth largest rubber plant in the United States, the largest luggage manufacturing plant, the major stockyards, and important plants relating to ceramics, atomic energy, missile manufacture, precision instruments, as well as control and nerve centers for distribution and services throughout a vast intermountain and plains region.

Like most Colorado cities, Denver has built its water system out of its own resources. When, in the depression period of the thirties, relief money was translated into public works for highways, schools, sewage treatment plants, public buildings and waterworks, Denver, like most municipalities, received some Federal aid for its water plant and for its sewage treatment works.

Aside from this public assistance which was furnished throughout the Nation to restore the movement of money, Denver's water system and the necessary corollary, its sewage collection and treatment works, have been built entirely with local funds.

This reliance on local funds has not been entirely a matter of choice. The national reclamation program has been geared mainly to the

production of food and fiber with aid to municipalities only as an incident and never on as favorable a basis as that available to the farming industry.

The great cities of the West would like some assistance, but have received little of it except as they may have benefited by Federal aid to navigation and flood control.

Because of the low permeability and depth of available ground water aquifiers, wells have not proved to be suitable as a reliable source of water supply for major urban developments in Colorado.

To the extent that ground waters have been utilized and may be hereafter utilized, this source of water supply is a welcome addition to supplies received from surface streams.

For the major development of the foothills region from Colorado Springs to Fort Collins, with the Denver metropolitan area at the hub, the great industrial and agricultural development—present and potential—of the Arkansas Valley, and the maintenance of western Colorado's present agricultural economy and western Colorado's yet unused and unbelieveably vast power potential from coal, oil shale, and uranium, the surface streams must afford the backbone of Colorado water supply.

I would like to divert for just a moment here. I don't mean by this to in any way minimize the importance of the ground-water surveys which are now being conducted jointly by the U.S. Geological Survey, the State of Colorado, and local communities.

We do need to map our ground-water resources because there are some areas which cannot probably be developed by surface streams. They simply do not exist at these locations.

Therefore, a ground-water survey is most important to Colorado just as is the topographical survey mentioned by Governor McNichols. These general surveys are quite important to our complete development.

I would like to supplement what the Governor said about topographical surveys. We have spent 3 years in the field trying to find a needed reservoir site. During the depression days we got WPA projects going to give a real topographical survey to the whole area in question and we were immediately able from that survey to pick a reservoir site for reservoir which has now been built and which is in use and the water from which you gentlemen use while you are here in Denver.

In 3 years we had not been able to find that site, but as a result of a topographical survey we found it very quickly.

So these and similar activities, mapping programs and ground-water surveys, are most important to the continued development of the region.

Now, urban water problems do not particularly affect those streams which flow from Colorado to the south, to the northwest, or to the north.

Urban problems do seriously affect those dependent upon the Arkansas River, the Platte River, and the Colorado River. These rivers serve the centers of population in the middle portion of eastern Colorado and potential urban development for an industrialized Colorado River Basin.

The Denver metropolitan area is located on the South Platte River. The demands on that river far exceed the water which flows in it. The Platte River normally flows high in the spring, tapers off by the middle of July, with virtually no water from fall until the next spring snow melt.

To give itself a year-round supply on a stream where there are more users and more demands than there is water to fulfill the necessary use and demand, the city and county of Denver has built the most substantial water-storage system of any city in Colorado. It is only by this water-storage system that Denver is able to live through years of drought and the perennial shortage which occurs each year when the Platte River diminishes to hardly more than a trickle.

A number of years ago Denver outgrew the ability of the South Platte River to provide for its continuing growth. It began taking water from tributaries of the Colorado River by construction of transmountain tunnels necessarily built at high altitudes because to construct the tunnels at lower elevations would have made their cost prohibitive by reason of increased length.

As of today, nearly one-half of all the people in the Denver metropolitan area are totally dependent upon the water supply received from tributaries of the Colorado River.

Furthermore, all of the new industry and every one of the 3,000 people per month who come to the Denver metropolitan area to be served by the Denver water system are dependent upon the growth and development of that part of the Denver water system which derives its supply from tributaries of the Colorado River.

This same dependance on the Colorado River is the condition of growth of all major urban development in Colorado.

Denver's vast water development system is now 40 years underway and will proceed on its present accelerated basis for more than 5 additional years and thereafter at a more moderate pace for decades to come.

Denver is spending, out of its own resources, $150 million derived both from current sales of water and from long-term bond issues. This pattern of self-help is quite in accord with what we are told is the philosophy of the U.S. Bureau of Reclamation as reported in the public press as the result of a speech given at Boulder, Colo., recently, by Elmer Bennett, Under Secretary of the Interior. He is reported to have said that as the West arrives at economic maturity it must expect more and more to depend upon its own resources for agricultural development and less and less upon the Treasury as represented by the U.S. Bureau of Reclamation.

Nevertheless, there are in Colorado, both in the Arkansas Valley and in western Colorado, areas which will be much more of an economic benefit to the Nation as a whole when aided by Federal reclamation—areas that have not yet achieved economic maturity to the point where they are independent of the Federal reclamation program.

Best planning will gear these developments to local urban work.

Another area in which it must be expected that the National Treasury will, with profit to the Nation, find it desirable to lend Federal assistance is in the field of treating the human and industrial wastes which arises as the byproduct of urbanization.

Because cities in the West have so largely exhausted their economic resources in the development of adequate water systems, they have

been hard pressed to find the resources from which they might protect the health of downstream communities.

The State of Colorado itself, up to this time, has found the problem of properly treating the wastes from some of its own institutions to be an almost economically insurmountable one.

The problem before this committee is that of the optimum development of the water resources in the Nation. The solution of this problem in Colorado, includes not only bringing about construction of the works necessary to make primary and initial use of the moisture which falls on its mountains and plains, but necessarily includes also the problem of reclaiming that water for a succession of uses.

Because of its location, high altitude, and at the center of the western part of the United States, Colorado's water runs down and away from Colorado in every direction to be used and reused over and over again. The utility of this water must be maintained, not only by use, but by reclaiming it for further use.

Now we come to the important matter so far as the U.S. Government is concerned and particularly as the Congress of the United States is concerned.

The cities, large and small, have become accustomed to meeting the burden of financing the construction of pipes, pump stations, filters, clear-water reservoirs and raw-water storage reservoirs. But they now find that the U.S. Government has adopted some practices which are casting new and virtually unbearable burdens on these cities.

The incomprehensible aspect of the situation to the cities of Colorado is that far off Washington not only gives our cities no money, but has inadvertently placed obstacles in the path of the development of these cities which have now become so immediate and overwhelming that relief must be given.

In order to develop their water systems, it is necessary for the cities of Colorado, especially the larger cities, to obtain rights-of-way across public domain which belongs to the United States and is controlled by one or more of its departments or bureaus.

In seeking necessary access across publicly owned land, our cities find themselves encountering Federal laws and regulations designed for the protection of all the people, but often actually operating to deprive the local people of an opportunity to utilize their own natural resources and particularly the most important of all these resources, water for human use.

We will not here dwell on the problem of whether the water of public streams belongs to the people of the United States, or the people of Colorado, and the other States. That problem is important, but not within the scope, as we understand it, of the present inquiry of the select committee.

We are quite certain that appropriate means will be devised to give sure protection to locally owned property rights in water resources necessary to the continued life of the American people.

Accordingly, we will confine this presentation to other problems.

The solution of these other problems can be stated very simply so far as development of the Denver metropolitan water supply problem is concerned. Denver is willing to spend the necessary money to secure an adequate water system and supply for the growth of the metropolitan area.

We have demonstrated this by authorizing the issuance of $115 million of bonds within the last 4 years.

What Denver cannot undertake is to compete with the Federal Government if the Federal Government, even totally unintentionally, seriously impairs the ability of the Denver Water Board to meet its water supply responsibilities. The people of Denver must look directly to the Congress for protection of its lawful interests.

Among the things Denver and the cities of Colorado need from the Federal Government, and especially from the Congress, is definite and positive assurance by legislation and administrative regulation that in the case of publicly owned urban water systems, rights-of-way for reservoirs, pipelines, waterways, power stations, powerlines, and all incidental features related to the development of a water system, can be secured promptly and on reasonable terms.

Cities must receive assurance that in the competition for limited water supplies the Federal Government will neither design nor authorize Bureau of Reclamation projects which are competitive with the municipal developments and projects which could not stand economic competition without the subsidy of Federal aid.

This means that the Congress must by law provide for and insist upon cooperation by the executive departments of the United States with the municipalities so that they may secure from the Federal Government as favorable treatment as if the Federal Government were a private landowner or a private financier.

Making some practical applications of the theories just stated, we proposed that Federal law, regulations, and practices be geared to the same type of economic realities which cities must use in planning their affairs.

Municipal government must recognize the recreational needs of its people, their health requirements, their requirements for creating an economic climate in which all shall have a fair opportunity to utilize the resource of the land.

First things must come first, however. Where use of limited water supply for fishing or hunting, then the recreational aspects of that water use must be postponed to the stark necessity of making a livelihood. Where the immediate needs of human life require a pipeline, a road, a transmission line, or the like, the desirability of maintaining unexploited wildnerness areas must yield.

This represents the thinking of the West with regard to the important day-to-day problems which we face. We realize that it is not only necessary to think right, but that it is also necessary to express these thoughts in clearly understandable legislation so that public officials cannot be pressured into action which will impair western urban development.

I think I have not otherwise said so in this paper, but the State Legislature of Colorado memorialized the last Congress in this regard and asked the Congress in effect not to adopt any wilderness legislation until that legislation had been thoroughly reviewed by a committee already created by the Congress, those findings had been made known throughout the country and opportunity for comment thereon had been afforded to those who will be affected by such legislation.

The CHAIRMAN. Do you think we could build a nation in a wilderness without disturbing the wilderness?

Mr. SAUNDERS. I am sure of it. I just came back from Washington and I know there is a wildlife refuge right there next to the road where you go by.

The CHAIRMAN. I thought you were talking about the one in Washington.

Mr. SAUNDERS. I very nearly got lost in the General Services Administration Building and I thought it was something of a wilderness all right.

The CHAIRMAN. I want to say I could not be in more complete accord with anybody than I am with you in the thinking you are expressing.

Mr. SAUNDERS. Thank you, sir.

The CHAIRMAN. I am very interested in that and very happy to have this very cogent expression of the principles you enunciated.

Mr. SAUNDERS. I am not at all surprised.

The CHAIRMAN. I speak for nobody else, but myself, and my position is binding neither on the committee or the Senate. You surely are talking my language.

Mr. SAUNDERS. I am not surprised in what you said. I heard you at the National Reclamation Association meetings from time to time.

These laws should be so carefully drawn that Federal employees in minor administrative positions would not be required to make constant reference on day-to-day problems to men in the highest positions of government. These men in high positions should be spared as much detail of day-to-day operation as possible, by legislation so plain as not to encourage interpretive deviation from broad principles by persons in any position in the executive department.

Inasmuch as adequately treated waste waters of a community represent a sizable water resource to areas downstream, we believe that the Congress should continue a comprehensive program of aid to municipalities for sewerage construction grants.

If construction grants are permitted to be made to individual communities in a metropolitan area for separate installations, we believe that each such community also should be entitled to its same share, even though it has elected to become a part of a joint venture on a metropolitan level. If this is not permitted, efforts toward the economy of cooperative action will be discouraged by Federal financing requirements.

Perhaps I ought to delineate that just a little further.

In the Denver area particularly, but I think the same thing is true elsewhere in the United States and in Colorado, we have satellite communities which have grown up around the city of Denver. They are quite zealous of their own independence and quite proud of their own contribution to the whole welfare of the State.

Consequently, perhaps they do not desire to annex to the city of Denver, or even to associate themselves in many ways with other adjacent communities.

But they do recognize that sewage treatment is a common problem of all.

As I am informed, and I am not well informed in this field, by Mr. Bob Peterson, who is present here, and is well informed, he is sanitary engineer of the city, I am informed that the communities around Denver today are endeavoring very vigorously to form a consolidated

and unified system of sewage treatment which will result in great economies.

Certain grants in aid by money from the Federal Government are in contemplation, but to the present thinking there has been an idea that while an individual city might receive a certain grant it would lose that grant if it joined with other cities in having a common program because only one grant is going to be made in an area.

The CHAIRMAN. That is not only certain thinking; that is the present law.

Mr. SAUNDERS. That is my understanding. I hate to quote from the law because I am not up on this branch, but that was my understanding.

Now it seems that this is not good economics because if all of these communities can get together and each one of them gets its own individual grant a great deal of overall expenditures can be saved. That is something that I believe this committee could well afford to take a positive stand on since the treatment of sewage is so important to the full utilization of our whole water resources.

The CHAIRMAN. I have just been getting my memory refreshed.

Both the House and the Senate have passed legislation calculated to meet the problem that you are talking about insofar as the limitations of the present law is concerned.

Two versions of the bill are now in conference and I, in my own mind, am certain that out of that conference will come a bill which will move in the direction of the meeting of the problem you are talking about.

It will be our profound hope that it will be accepted by the administration.

Mr. SAUNDERS. If there is something that we could do at that conference, or after the conference, I hope that Senator Carroll will let us know about this because we are anxious to get whatever testimony might be valuable to the Congress in determining what its policy should be.

The CHAIRMAN. The action of both Houses is entirely consistent with your position?

Mr. SAUNDERS. Good.

The CHAIRMAN. The differences in the bill, I do not believe, are primarily in that field of the matter covered by law. The problem will be in connection with securing the acceptance by the administration of the law which the Congress in my judgment, will surely pass.

Senator MARTIN. May I comment?

The CHAIRMAN. Senator Martin.

Senator MARTIN. I should add also that I am not sure myself that the bill now in conference goes far enough to cover the situation you face here with all the municipal groups about the city of Denver. It is rather limited.

The CHAIRMAN. I think it fixes it so instead of being one grant available to the area, there would be at least four. Is that not in it?

Mr. SCHAD. Senator, I am not sure both bills are the same. The Senate bill has that, but I am not sure that it is in the House bill.

Senator MARTIN. I know there is a limitation on the bill that we had up that would not go far enough to cover this situation described by the witness.

The CHAIRMAN. It would be moving in that direction.

Senator MARTIN. It would be moving in that direction. I think we have reason to be optimistic about further movement in that direction, based on the situation developed in our hearings on this last legislation.

Senator CARROLL. I want to say to Mr. Saunders what we will do. In our office we will examine both bills and find out what the situation is and keep you informed of the results of the conference and we will also follow and help where we can.

Mr. SAUNDERS. That will be very much appreciated.

Senator CARROLL. Because it is very important to Colorado, as Mr. Saunders indicated, and Denver and your surrounding counties.

Mr. SAUNDERS. It is so important here.

The CHAIRMAN. Go right ahead, Mr Saunders, with your statement.

Mr. SAUNDERS. As we have pointed out, in meeting their water supply problems the cities have not received the benefit of the Federal Treasury to the extent that navigation, irrigation, flood control, and electric power have received such benefits.

Having so largely exhausted their financial resources in securing a primary water supply, and in order to protect the general health of the people of the United States who travel so quickly and frequently from place to place, that the health in one location is of importance to all locations, it is important that the Federal Government extend and improve its aid for sewage treatment.

In conclusion we point out that securing, purifying, distributing, and treating water supplies is a matter of local concern throughout the United States. This is typically a municipal problem.

In the vast majority of cities in the West, the problem is met by publicly owned plants. This is neither a State nor a Federal problem. Both State and Federal Government, with some exceptions, look to municipalties to furnish all water supply needs for the citizens as well as for government.

Federal legislation must be geared to allowing municipalities a full and wide discretion in selecting and executing the means for furnishing urban water supply.

Only one addition that I might make in answer to some questions that Senator Kerr has asked. Hearing those questions I sent for a copy of a bulletin, Bulletin No. 1 of the Colorado Water Conservation Board, which I know Mr. Sparks did not have here. This bulletin is a report made in 1953 by Leeds, Hill & Jewett, engineers, of Los Angeles, on the water supply available for use in Colorado. This bulletin is the first and preliminary to a series of studies being made by Colorado.

This bulletin is now being thoroughly reviewed by the State water conservation board under the direction of its chief engineer, who is present, Mr. Cooper, and is subject to additions and extensions and revisions. But on the whole this bulletin shows that there is available for use in Colorado about 1,450,000 acre-feet of unused water which has been allocated to Colorado by compact, and which stream studies show will be available for the development of this State.

I hope no one could receive an impression that Colorado does not have adequate resources for a very major development. The water resources which we have referred to as being developed by Denver

are well within the terms of available water supply as set out in this Bulletin No. 1 of the Colorado Water Conservation Board.

And we expect that if we are given the cooperation of the Federal Government in meeting our problems that we can meet a tremendous development in this foothills region which I mentioned from Colorado Springs to Fort Collins and that we can allow this region to grow to where it will be one of the major cultural, educational, and economic centers of the United States.

We do not lack for water. We must, however, carefully use the limited supplies which we have and so using those supplies can create a dependable base for a major metropolitan development for the United States.

Thank you.

The CHAIRMAN. I would say that the committee would be very happy to have the latest version of that report that would be available ahead of the time when we must close our books as to the data that will be included in the formulation of our own report. And if you or Mr. Sparks would keep in touch with our director, Mr. Schad, so that we might have that prior to the date of the closing of the receipt of information by us we would be very grateful.

Mr. SAUNDERS. I am sure they will make that available.

The CHAIRMAN. Fine.

Senator CARROLL. Thank you, Mr. Saunders. A very fine statement.

We are now about to have testimony on a field we don't hear much about, that is basic research in water and climate. One of our distinguished scientists of Colorado, not only known in Colorado, but throughout the Nation, will be our next witness and I now ask Dr. Walter Orr Roberts to come forward and give his testimony, please. Dr. Roberts is the director of the high altitude observatory in Colorado. He has been of great help to me. I do not know much about science but I listen very carefully to Dr. Roberts.

Would you proceed, Doctor?

TESTIMONY OF WALTER ORR ROBERTS, DIRECTOR, HIGH ALTITUDE OBSERVATORY OF THE UNIVERSITY OF COLORADO

Mr. ROBERTS. Thank you, Senator Carroll.

Mr. Chairman and members of the committee, I would like to present my testimony in two parts, if I may, briefly, the first in which I speak specifically for the University of Colorado, the second in which I speak for myself and my colleagues at the high altitude observatory which is a private, nonprofit research educational organization closely affiliated with the university.

In the first part I would like to review very briefly the research that is going on at the university dealing with waterflow in the upper Colorado River and its relationship to weather developments in the high atmosphere.

The CHAIRMAN. I wonder if you are going to follow the apparent outline of your paper wherein the prediction of drought will be the first thing to which you address yourself?

Mr. ROBERTS. I can do that, sir. I had intended to speak briefly of the other topic first.

The CHAIRMAN. Then you follow that which will be most useful to you and I will accommodate myself to it. I must say I am tremendously interested in that phase of it.

Mr. ROBERTS. Thank you. Perhaps it is very easy for me to change the order. So let me change the order that I had planned.

The CHAIRMAN. Fine.

Senator CARROLL. The reason for this, Doctor, is I said you were a great prophet about drought and Senator Kerr has expressed a deep interest in your prophecy.

Mr. ROBERTS. Thank you.

Then I would like to deal with the portion of my testimony which is contained in the written record that I am submitting to the committee and in this I am speaking for myself and for several colleagues who are named in the written testimony.

In our view this problem of forecasting of recurrent droughts is perhaps one of the most challenging problems facing the entire Nation today. The question of whether it is possible to many years in advance forecast these trends of drought and the companion question of whether it will become possible for us to do something of a practical nature in weather control that will be of broad regional and national significance.

The potential of the consideration of these questions may even in the future of our Nation outshine the importance of atomic energy research. It has been dramatized, I think, in a way very spectacularly by the recent Russian proposal, for example, to build a huge dam across the Bering Strait, a dam some 50 miles in length, that would change the flow of water through the entire Arctic Ocean and convert vast areas of the world that are now completely frozen wastelands into fertile plains, a proposal, by the way, suggesting a joint United States-Russian construction at a cost of over $17 billion.

This area is dramatized by this but is not confined in any way to modification by dam construction and I wish to speak specifically of what might loosely be called atmospheric science and its potential in drought forecasting.

As you know, the earth is whirling in space some 90 million miles away from the sun, which is constantly firing off into space both electrified particles and great clouds of X-rays and ultraviolet. The sun is also giving the bounty of light and heat to the earth. I am interested to note that in 4 days the sun gives off to the earth more energy than all of the known fuel reserves on earth, all of the gas, coal, atomic energy reserves—more in 4 days of such light falling onto the earth than this amount of energy. Even though, by the way, this part falling on the earth is less than one-millionth of the energy given off by the sun itself.

The field of research at my institution, the high altitude observatory, is to study this output of the sun and its various effects on the earth. Our research reveals that there are at least at certain occasions definite apparent influences of the sun on the weather.

I would like to review these just very briefly because they are at the forefront of our growing knowledge.

The CHAIRMAN. Let me ask you this question right here.

You have studied, I would presume, the precipitation pattern over a long period of years with reference to certain given areas?

Mr. ROBERTS. Yes, the Great Plains in particular.

The CHAIRMAN. For what period of years?

Mr. ROBERTS. Well, through indirect measurement way back to several thousand years ago.

The CHAIRMAN. But with reference to accurate measurements for how long?

Mr. ROBERTS. The turn of the century, perhaps.

The CHAIRMAN. We had some testimony in Kansas based on what I was informed to be accurate information of the record of precipitation for a period of——

Mr. HOYT. 1900.

The CHAIRMAN. I thought it went farther than that.

Mr. HOYT. It may have. I do not have the record.

The CHAIRMAN. I thought it included a period of 90 years.

Mr. ROBERTS. Yes.

The CHAIRMAN. Those records are available, aren't they?

Mr. ROBERTS. Yes. There are reasonable weather records. Mr. McDonald could correct me if I am wrong. There are reasonable weather records covering large areas back to about 1870.

The CHAIRMAN. I believe that is what they gave us there, was 90 years.

And that compilation indicated a very definite pattern. First, a period of generous precipitation and then a period of less precipitation and then a definite period of drought.

Mr. ROBERTS. Yes.

The CHAIRMAN. It appeared to me that regardless of what caused, that, whether it was by action of the sun or reactions taking place on the sun by reason of atmospheric situation or conditions around the sun, nevertheless over the 90 years there was a very definite pattern of drought, semimoist periods and moist periods.

Now, generally speaking, does your research indicate a similar finding with reference to the Great Plains area or the area that you studied?

Mr. ROBERTS. Yes, sir, and in specific I would like for a few minutes to testify on the point of the degree to which this recurrence or apparent recurrence can be forcasted or the degree to which future research will develop the means of its forecasting. But the answer is "Yes."

The CHAIRMAN. Here is the question that I would like to have you answer. Is it your belief that if we arrive at the point of being able to forecast drought, that means we can forecast moisture as well as drought, which will be based on visible conditions in the atmosphere and the effect which it will be expected to have, or will your forecast be based largely on belief of a recurrence of the historic pattern or both?

Mr. ROBERTS. It will actually be on both. But primarily on observation of phenomena besides just this recurrence; in other words, primarily on observation of—you are asking me a very difficult question.

The CHAIRMAN. I know I am. I understand that.

Mr. ROBERTS. Because this is an area of speculation today rather than an area of completed science.

The CHAIRMAN. If we have a pattern based on actual recorded data, that is not speculation.

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Mr. ROBERTS. No. But today the research does not show a clear-cut pattern based on observed, say, features of the sun or features of cosmic dust from outer space.

The CHAIRMAN. If it shows a very definite pattern of 5 years of moisture and 10 years of mixed amounts and 5 years of drought, let us say, and while that is just an illustration, and not a statement based on what it does show.

Mr. ROBERTS. Yes.

The CHAIRMAN. If it does show such a pattern, would that not be of great significance in the matter of forecasting?

Mr. ROBERTS. Yes; it would, indeed. But may I speak for a couple of minutes to this specific point?

The CHAIRMAN. Yes.

Mr. ROBERTS. Although, again, I had intended to put this further in my testimony.

If we look at the Great Plains area specifically, say the southern Great Plains, from, say, south of the Dakotas down to the Texas Panhandle and east of the Rockies, but, say, west, roughly, of Kansas City, if we look at this area we find that there have been two very pronounced, very severe droughts, one in the mid-thirties and one in the mid-fifties. These have not encompassed precisely the same areas. But these two droughts have been spaced 22 years apart, or roughly, 20 years apart.

The CHAIRMAN. Would you like to see this now or later? I will tell what I believe. I believe I would ask you to review this, subsequent to your appearance here, and then give the committee the benefit of your reaction to it.

Mr. ROBERTS. I will be very happy to do that.

The CHAIRMAN. I think that is the way to do that.

Mr. ROBERTS. But as I was saying, the examination of the past records of the Great Plains, for example, reveal these two severe droughts 20 years apart, roughly. The striking thing that leads one to suspect that this may be a specific recurrence is the fact that both of these times were times of very, very low activity of the sun. The sun was deficient in the number of sun spots. The number of great solar eruptions of the kind—I actually brought a couple of pictures along which I might give to you. And at this time of low solar activities these severe droughts developed. We do not have a theory to explain why the low solar activity produced the droughts, but——

The CHAIRMAN. But you do know they occurred simultaneously?

Mr. ROBERTS. Yes, sir. But the thing that makes the problem perplexing from the research standpoint is that there have been comparable periods of low solar activity without comparable droughts.

The CHAIRMAN. That is the question I was going to ask you.

Mr. ROBERTS. Yes, sir.

The CHAIRMAN. Yes.

Mr. ROBERTS. This is the thing that leads us to doubt the efficacy of simply forecasting on the basis of a recurrence which is not fortified by an examination of other factors that are not yet observed and that are not yet known to recur. Specifically, it is the examination, the effort to disclose these other factors that will form the basis of the successful method of the forecasting of recurrent droughts or of semirecurrent droughts.

For example, on the basis of this 20-year cycle, if you call it that, in the Great Plains, one might expect that a drought should have occurred around 1915 or 1914. This was not the case, apparently. One might expect that a drought would occur in 1970–75 if the solar activity and the low level of it and the 20-year recurrence are to be trusted, and this in my personal opinion, and now disassociating myself specifically from some of my colleagues in meterology, this is my opinion of the most probable future severe drought period in the Great Plains.

On the other hand, we do not yet have the observations of those additional factors that were in play in the 1915 period and that prevented the occurrence of drought.

The CHAIRMAN. Is the data available that will enable you to ever be able to define them, outline them?

Mr. ROBERTS. You are asking me to make a statement of faith. The data are not today available but our solar research, for example, at our station at Climax and associated solar observatories, these researches are going fast, at such a pace we are making measurements of features of the sun we didn't know existed years ago. For example, in space between sun and earth we know there are extensive areas where magnetic fields are present; these fields guide the electrified particles shot out into space. So one of the eruptions, of which I have, again, a picture, shoots out from the sun it may strike or miss the earth, depending on how these magnetic fields happen to be tied up in space.

The CHAIRMAN. Whether or not deflected by them.

Mr. ROBERTS. That is correct; yes, sir. To come back to the specific results of our own work now, the suggestion that there may be an influence of this solar activity changing the weather and perhaps producing drought cycles, we find that when these solar-electrified particles strike into the North Pole regions and produce the luminous glow of the northern lights we find there is some evidence that in the days following these brilliant displays of the aurora, there is a change in the weather patterns on a world scale and a change of such a nature that it very often brings into central North America a very severe and deeply penetrating storm system. Mr. McDonald has done most of the research on this.

The CHAIRMAN. Not necessarily one being the result of the other but both being the result of a common cause.

Mr. ROBERTS. Yes, sir. Both being the result of some kind of energy sent in from the sun that has produced on the one hand the aurora and on the other hand the intensification of the storm system.

The CHAIRMAN. Let me ask you right there. You made a statement that I am interested in. I had indulged in the assumption which I thought was general that the exact explanation of the origin and cause of the occurrence of northern lights was not known.

Mr. ROBERTS. Well, we believe we know it, sir.

The CHAIRMAN. How long a time have I remained ignorant in that regard when information was available to have dispelled it?

Mr. ROBERTS. I think this depends to a certain extent as to which expert you consult. In truth there are many unsolved questions about the occurrence of the aurora. But I think almost all of us agree that the basic origin is to be found in clouds of gases ejected

from the sun which strike the earth some 1 to 3 days later and produce a luminous glow of the northern lights. What is unknown is the details of how the energy of these electrified particles can actually produce the kind of luminousness that is observed and not a doubt on the question as to whether these particles have actually come from the sun and the recent discoveries of the Van Allen radiation belts from the satellite research have greatly changed the picture of knowledge in this field in just a matter of months.

The CHAIRMAN. Then I need not feel too chagrined about being this late in catching it?

Mr. ROBERTS. No, sir.

The CHAIRMAN. All right.

Mr. ROBERTS. We find, for example, that the Van Allen belts can store the solar particles so they don't produce their entire effect just at the time they reach the earth but they can be stored maybe as much as 2 or 3 months before their ultimate effects come in a brilliant display of the aurora. It is a very complicated and fascinating field of research and it is difficult even for us who work in the field to keep up with the month by month developments. This is one reason why I believe that there is such a fertile field of investigation of the relationship to droughts lying just before us.

But to come back to my point of the development of our research, these deep penetrations of storm systems can be very severe; for example, the temperatures in Florida can be colder than the temperatures in parts of Alaska when one of these very great outbreaks occurs. We have studied three winter seasons now in great detail at very high altitudes and have found that more than 50 percent of all of the major storm systems that have penetrated deep into the United States bringing great amounts of precipitation have followed specific instances of brilliant aurora produced in turn by the sun. So this suggestion is to us that there is a cause and effect relationship not yet fully understood but in play. If you examine the probability that this is just a chance association it is less than one in a million. We really have hold of something that looks like an important new research result. This suggests if we can carry the investigation of it all the way to its origin that we may someday be able to forecast—from our expected ability to forecast the solar streams when they are ejected—we may be able to forecast some time in advance the periods of recurrent drought.

Many of my colleagues in meteorology would disagree with my optimism but they would not disagree about the virtue of pursuing this research with full vigor.

So the question then becomes that of trying to understand how the variations of solar activity or of whatever other causes are operative to produce these semirecurrent droughts to try to understand these mechanisms so what now are dangerous speculations based purely on recurrence can become sound scientific theories.

Using the observed recurrences perhaps as a beginning or a basis. You see the solar activity rises and falls every 11 years, 10 to 11 years. The cycle has been known to exist back to the time of Galileo in 1611 when he first observed sunspots. There have been regularly cyclic progressions yet climate has not followed regular cyclic 11-year progressions. There are places in the earth where you think you can see signs of this. We know in certain instances when we get a very

great increase of solar activity it will produce in one area a drought at one time and in the similar area at another time it will produce abundant rainfall. What has occurred in the intervening time to change the effect of the increased solar activity to just the opposite of what it was before? These are the kinds of very difficult scientific questions that have not yet been answered and it is on this that the uncertainty of the outcome of our research depends. But all important research has these uncertainties. It is just sort of the nature of the beast and if we knew the answer we wouldn't be doing the research, we would be making the applications.

Now there are a few other points that I would like to testify on.

The CHAIRMAN. Before you go there, does your research go into the field of predicting of mild winter or a severe winter?

Mr. ROBERTS. This is the goal. At the present time it is not possible in practice to do this. I think it is fair to say that at the present time it is not possible to make weather forecasts of any reliability beyond 30 days.

The CHAIRMAN. Is there any basis to have faith in, let us say, the evidences which our Indian brothers have long used to base a feeling of there being an approaching mild or severe winter?

Mr. ROBERTS. No. I think it must be confessed that at present there is no scientific basis for these hunches about the coming mildness or severity of a winter.

One cannot be too dogmatic about this. For example, I believe the likelihood of strong westerly winds and the developing drought in the 1970's but until the scientific research is done this is only a hunch and there is a great difference between a scientific result and a hunch. Sometimes the hunch is—

The CHAIRMAN. They are not entirely unrelated?

Mr. ROBERTS. That is correct, sir. Sometimes the hunches find scientific basis. But the hunches without the scientific theory are not safe to be trusted and they are not safe to develop, for example, national water policy.

Senator CARROLL. You referred to the solar stream. Does that in turn affect the jetstream? Is that what you meant by the westerly winds?

Mr. ROBERTS. Our belief is that the solar streams striking the earth releases energy which in some way causes the jetstreams in turn to develop bends and when these bends occur the cold air of the Artic and the warm air from the Tropics is redistributed drastically and this produces changes of weather.

Senator CARROLL. Scientists all over the world are studying this?

Mr. ROBERTS. Yes.

Senator CARROLL. Do you know what the Soviet Union is doing in this field?

Mr. ROBERTS. This is a very, very interesting point. I just completed fairly extensive study of the Soviet literature in this field. If I had another hour to testify I could tell you some fascinating things about it but they are making rapid progress and many ways are ahead of us in this particular field.

The CHAIRMAN. Would you extend those remarks for the record and give it to us?

Mr. ROBERTS. I would be glad to, sir.

The CHAIRMAN. If it would not be a burden we would appreciate it.

Mr. ROBERTS. Yes, I would be glad to do that.

Senator CARROLL. If any group of scientists of any nation could control the jetstream they would have made a great advance, would they not.

Mr. ROBERTS. Yes, indeed.

The CHAIRMAN. It might not be. It might be an advance for some and not for others.

Mr. ROBERTS. Let me again change the order.

Senator CARROLL. I was thinking of that nation, you see.

Mr. ROBERTS. Yes. Let me speak to that point also because I had planned to make some remarks on that toward the end of my testimony. But let me put them in here now.

Senator CARROLL. All right.

Mr. ROBERTS. When a drought occurs in the Great Plains it occurs because of a combination of circumstances. It occurs first because strong westerly winds develop and persist. These westerly winds at jetstream levels, this means 30,000 feet level above the surface of the earth, these winds come from the west, are raised up over the mountains, as they rise over the mountains the moisture is dropped out on the western slope. But then as they come on into the plains, having come over the mountains, they are desiccated.

The CHAIRMAN. Dry?

Mr. ROBERTS. They are so dry, yes, that they take moisture from the surface of the ground and from lakes and they increase the evaporation. But they also have another effect. Because of their westerly flow from the west to the east, they deflect the invasions of gulf air, of warm moist air from the Gulf of Mexico, which would normally invade the region just on the eastern side of the Rocky Mountains and would produce rain when it mixed with the cold canyon air coming also down from the north. During the period of westerly winds this air is pushed farther east and no precipitation comes to the Dust Bowl area and the Dust Bowl develops and the wind, the dryness of the area and the absence of precipitation are what produce the catastrophic effects of a drought.

Now, if the kind of changes of outbreaks of severe storms that I have spoken about following these solar activity were abundant in a given year then moist air would be brought into the Great Plains area.

The CHAIRMAN. They would, to say it one way, override the westerly flow?

Mr. ROBERTS. Yes; they would break up the westerly flow. So that generally the period of strong westerly flow and the period of these frequent outbreaks happen at different times. They are mutual exclusive. So the faint goal, if you want to put it that way, the goal, the possibility that lies behind this research is that perhaps man will learn the way to do what the streams of particles from the sun appear to be able to do, man may learn ways to deflect these jetstreams by the release of suitable amounts at suitable times of the proper kinds of material into the atmosphere and no one knows how much of this material will be required. We already know that when the sun does it a very small amount of energy is involved and that——

The CHAIRMAN. Not relatively—not actually but relatively. I believe you said we get the benefit of about one-billionth of the heat generated and expelled into space by the sun.

Mr. ROBERTS. Yes.

The CHAIRMAN. But that within 4 days' time that represents energy greater than the combined energy-producing capacity of all of the energy fuels in the earth.

Mr. ROBERTS. Yes. But this energy that produces the bends of the jetstream and the storm systems is not the sunlight, not the heat, but it is just the energy of those few electrified particles.

The CHAIRMAN. But the extent and capacity and specifications of those are still a matter of less than accurate information.

Mr. ROBERTS. Yes, sir. But we are quite certain that they represent small amounts of energy compared to the energy that ultimately shows up in the developing storm system. So that the amount of energy necessary to dispel a drouth is probably millions of times greater than the amount of energy that comes from these electrified particles. But by virtue of that fact perhaps there is a possibility that man will learn to release those one-millionth of the necessary energy particles in the right place and will learn in essence to put his finger on the trigger of the trap that the atmosphere represents. You see this jetstream is like a trap that has been set. Nature has learned to press the trigger and release the coiled energy of the spring producing a storm. Perhaps man will learn some way to put his finger on the trigger with drastic international and national and economic and water consequences that it is almost frightful to think about.

Possibly the future will see the war of weather control if these things develop.

The CHAIRMAN. I would say there is no doubt of it.

Mr. ROBERTS. In some ways I feel as I did about atomic energy, I wish nature were constructed otherwise and it would turn out to be impossible.

Unfortunately, we don't have control of that or perhaps fortunately.

In any event, the lands of the Great Plains and the Southwest are the most susceptible to this kind of variation. Senator Kerr, when you spoke of when we did this calculation with Mr. Sparks of 15 or 16 million acre-feet per year, the water resources of Colorado, we were speaking of a long-term average. In the Colorado River, for example, if I remember these figures correctly, the fluctuation can be from as low as about 6 million acre-feet or as high as about 20 million acre-feet.

The CHAIRMAN. I think the long-term average of the flowage of the Colorado, that last figure is 18½ million acre-feet.

Mr. ROBERTS. Yes, I might have these figures a little wrong. But anyway, the variation is by a factor of three or more. We cannot say with confidence by any of the methods available to science today that we are not next year going to head into a sustained period of never over 10 million acre-feet. We cannot say that. We don't have the knowledge to do that. These things are today unpredictable. We do know that the variations are largest in the regions that are most arid. Thus, our Great Plains area and our Southwest, our West throughout the West, is the most susceptible to the disastrous consequences of unpredicted drouth. We also have a very bad ten-

dency, I guess it is just human, when we have a few good years of rainfall, we say conditions have returned to normal and we immediately set about to use all of that normal rainfall. When the normal really comes back we cry for disaster relief.

I think the only thing that can be said is that basic research on the cause of these droughts, basic research and the processes of the atmosphere is the one thing that will take chance out of the forecasting of the variations of the rainfall resources over these arid lands.

I think one can safely say that within the next 25 to 50 years a severe drought equal to or exceeding the drought of the thirties and fifties can be anticipated in the Great Plains area and in the Southwest in general.

The CHAIRMAN. It would certainly be unjustified optimism to not expect it.

Mr. ROBERTS. It would be unjustified optimism to plan without this as the most likely prospect. No one can predict today how severe that will be. No one can predict exactly where it will occur. The hope is that by the development of research we will be able to predict and to control these trends.

If the odds were 100 times worse for progress in this field I would say that this would justify intensive national effort. I would like to make three specific recommendations.

The CHAIRMAN. Before you do, let me translate your statement you just made into the international situation.

Awhile ago you said in your statement that the Soviets were ahead of us in this field of research.

Mr. ROBERTS. In some aspects of it, yes.

The CHAIRMAN. And you have just said that we must make a great effort not only to be able to predict but to control.

Mr. ROBERTS. Yes.

The CHAIRMAN. And that your hope is that within 25 to 50 years we will have obtained that objective.

Mr. ROBERTS. Yes.

The CHAIRMAN. The significance of that has to be that within that period of time or less the Soviets will have learned not only to predict but to control.

Mr. ROBERTS. Yes.

The CHAIRMAN. Then will come probably the greatest potential of explosive action that we have yet to face.

Mr. ROBERTS. Yes. I quite agree. I should say, further, that the probability of developing methods of prediction is far more optimistic or far greater than the probability of developing methods of control. If I were called upon to estimate today whether we will in fact achieve, whether it will turn out to be possible to control the development of these great storms, my estimate would be "No." But there is the possibility and we cannot afford to let the research to rule out, to let that——

The CHAIRMAN. If it is to be found we better find it?

Mr. ROBERTS. If it is to be found we better find it and find it first.

The CHAIRMAN. Go ahead.

Mr. ROBERTS. I would like to make three specific recommendations. The National Science Foundation, of course, has been charged with the promotion of national interest in weather control and weather

forecasting research. I think that these goals, the goals that have been stated by the Foundation are highly relevant to the development of our water policy and that they must be supported adequately by congressional appropriation.

I have carefully studied the need and the National Academy of Sciences Committee report and I agree that the scale of meteorological research in this country on questions like this must be stepped up by a factor of approximately 10 and the principal problem here is not just money but it is manpower. And I feel that the Science Foundation has set wise and realistic goals and they deserve intense, complete support.

Second, I feel that improved observing programs in areas like the high mountains of Colorado should be continued and should be extended like those of the USGS, the Bureau of Reclamation, and various State agencies. I think, also, that State-initiated research programs like the present cooperative program going on at CSU and at the University of Colorado and at the high altitude observatory must continue and must be expanded not only in Colorado but in many other States. And I think it would greatly broaden and greatly stimulate the support of basic research from local levels with local initiative if funds of the type allocated for our present program were specifically matched federally. The amount of money involved would be very small.

But I think the significance of this to the improvement of research would be enormous.

Third, I think that our planning has got to include realistic preparation for a severe drought in the Great Plains, in the Southwest, as I have said, within 25 to 50 years.

Population growth in this drought-prone area should be intelligently planned and sharp restrictions should be made on water-hungry industrial developments unless we are able to slake with some tangible and specific technological developments the thirst of that kind of an industrial use.

And these, sir, are my specific recommendations.

The CHAIRMAN. I want to express my deep appreciation for your statement and your observations and the testimony that you have brought us. I think it was quite significant to the scope of inquiry of this committee and also to the extent to which the need for knowledge such as you have indicated is possible to obtain exists and I think that that need should by every means possible and certainly through the operation of this committee be made known far and wide.

Mr. ROBERTS. Thank you.

The CHAIRMAN. In order that greater authority and effort may be given to the meaning of it.

Mr. ROBERTS. Thank you.

The CHAIRMAN. I appreciate it.

Mr. ROBERTS. With your permission, sir, may I write the part that I had intended to give as the first part of my testimony and have that included in the record?

The CHAIRMAN. Indeed you may.

Mr. ROBERTS. Thank you.

Mr. CARROLL. May I suggest, Mr. Chairman, that the entire statement be put in the record?

The CHAIRMAN. I would say this, in the light of the statement he has already made it would probably serve the committee better and also suit his purposes better for him to submit a statement which he thinks should go into the record in addition to the oral testimony he has given us.

Mr. ROBERTS. I would like to do that, sir, with your permission; yes.

Senator CARROLL. Thank you very much, Doctor.

Mr. ROBERTS. Thank you.

Senator CARROLL. I knew you would furnish valuable information to the committee. This is my adviser, I want the chairman to know, on scientific matters.

Thank you, Doctor. Your complete statement will now be submitted.

(The matter referred to is as follow:)

STATEMENT FOR UNIVERSITY OF COLORADO BY WALTER ORR ROBERTS

Senator Kerr and members of the committee, I am happy with the opportunity to testify today before your committee. My testimony appears in two parts: (1) in this portion of my testimony I shall speak for the University of Colorado, and shall review briefly present research at the university dealing with waterflow in the upper Colorado River and its relationships to weather development in the upper atmosphere; (2) in a second portion of my testimony I shall be speaking for myself and colleagues at the high altitude observatory, and will examine the larger and more controversial questions of research on long-range predictions of droughts, and of the potentialities of new scientific developments in weather control and weather forecasting. Both of these areas of research have intimate connections to the development of sound national water policy. I shall now address myself to my testimony for the University of Colorado.

RESOURCES DEVELOPMENT PROGRAM

The University of Colorado, in cooperation with several sister institutions, is in the beginning stages of a sustained program of scientific research and graduate study in the area of resources development. The new resources development program embraces consideration of all resources of the State, including mineral, timber, clear air, agricultural resources, etc. Research on water resource development and conservation is obviously a central aspect of this program, since water is one of the State's most critically necessary resources.

Your committee has already heard the testimony of Prof. Morris Garnsey who directs the resources development program. We at the University of Colorado consider ourselves extremely fortunate to have a man of Professor Garnsey's dedication and ability to guide the program, and believe this program greatly merits your interest. We look for significant developments, with continuing assistance in the years ahead from the several institutions with which the resources development program is now cooperating.

PAST AND FUTURE VARIATIONS IN STREAMFLOW IN THE UPPER COLORADO RIVER

An example of research in progress at the University of Colorado on water resources is a present task involving three institutions: the University of Colorado, Colorado State University, and the high altitude observatory. This particular program has a threefold goal, and will be accomplished over a period of 2 years.

The first goal is to complete a study of the variablity of streamflow of the upper Colorado, examining past history in considerable detail, and developing statistical analyses that give limits of probability of variations for the stream insofar as the past is a predictor of the future.

The second program is to correlate all of the actually observed weather elements available in the upper Colorado Basin with the actual streamflow data in an effort to explain lag, storage, evaporation, etc., before the rainfall or snowfall actually turns up in riverflow. This will permit considerable expansion of knowledge regarding the responsiveness of streamflow to these weather elements, and may also permit us to extend the range of knowledge

of actual streamflow further into the past. This portion of the research will have several general research applications beyond the specific results of the problem.

The third portion of the joint work is a basic research effort to relate streamflow to high atmospheric windflow at the "jetstream" levels. The ultimate hope of this portion of the program is applicability of advances that may occur in long-range prediction to the specifics of the upper Colorado River Basin.

This tripartite research has been supported by the Colorado Water Conservation Board, in its initial phase, and it is planned that the coming phases will also have the broader support of adjacent States that have upper Colorado Basin interests.

It takes no elaboration, obviously, to show that this approach to the problem goes far beyond the confines of the upper Colorado or beyond the confines even of a specific region. It is a research of basic national interest. If the research here is successful it paves the way for similar applications to other basins. We feel, thus, that here is an example of research with far broader implications than the particular region in which it has been conducted.

This, Mr. Chairman, completes my specific testimony on behalf of the University of Colorado.

Testimony of Walter Orr Roberts, Director, High Altitude Observatory of the University of Colorado

Recurring Droughts—A National Problem

Mr. Chairman and members of the committee, it is indeed a pleasure to have this opportunity to appear before you and speak on the subject of recurring droughts and other fluctuations in the trends of weather insofar as they affect our Nation's precious water resources. I speak for myself as an individual, and for my colleagues, Norman J. Macdonald, Paul R. Julian, Robert J. Low, and Bernhard Haurwitz of the scientific staff of the high altitude observatory. An important portion of our research work is devoted to this subject.

THE PREDICTION OF DROUGHT

One of the most challenging scientific problems ever faced by man lies in the field of long-range prediction of the recurrence of sustained droughts and periods of abundant rainfall. Related to this is the question of the extent to which man may learn, someday, to control the now seemingly capricions vagaries of climate. It is today impossible to state with authority whether either of these problems will yield to solution. But strong effort is justified, because there lies in their solution vast potential benefit to all mankind. But let me first explain briefly how we at the high altitude observatory became interested in these matters.

The central goal of our work has been to understand the influences of the sun on the earth. The sun, of course, is the source of almost all of the energy used by man. Its steady bounty of heat and light is enormous. In less than 4 days the sun showers the earth with as much energy as there is in all of the stored fuel reserves known, as much as all the oil, coal, and atomic fuel known on the earth.

The sun does more than this, however. It also lights the auroras in polar regions, deflects the earth's magnetism, channels radio signals around the world, and pushes about the winds that control world weather.

Some of the sun's emissions, invisible to the eye, vary radically. And with these changes there are interesting earth effects. A major part of our work is devoted to studying these sun-earth effects. If we succeed in this effort our results may influence the well-being of people all over the world.

One of the great riddles, for example, is droughts. What causes them? Is there a pattern in their recurrence? Can they be predicted, so that we may take account of this knowledge to conserve our precious water resources? Can we forecast periods of ample rainfall in agricultural areas to assist in crop planning—or the paths of severe storms, like hurricanes, to help save lives and property? Is there a chance that man can control world climate or alleviate severe regional droughts?

The answers are not yet known. But such questions, in recent years, have become an important part of our research at the high altitude observatory as clues have come to suggest that one of the factors in climate change is the changing activity of the sun. And study of the sun, both from our high altitude

station at Climax and our research center at the University of Colorado, has been our traditional field of special knowledge.

My own personal conviction is that the problem of how we, as a nation, manage our dwindling water reserves is our most important long-range economic and social problem. For us here in the West it is easy to understand the significance of water. But it will be only a few years before other parts of the Nation are also made acutely aware of this. My conviction about the central importance of water conservation lies behind my determination that we at the observatory will push all possible constructive effort into the problem of understanding the causes of large scale weather changes, either of drought or of flood. I believe, moreover, that major clues to these changing weather and climate trends will be found in studies of the way the sun's changes affect the earth's upper atmosphere. There are, however, many experts in meteorological sciences who disagree with me.

Many other research teams are at work on problems of long-term weather and climate changes. I shall try to outline, below, some of the important steps that must be undertaken if these various groups are to succeed in making sound overall research progress. Many seemingly disparate and divergent modes of attack to the problem are being simultaneously undertaken. And I think this highly proper. It is perhaps the touchstone of American scientific inventiveness, our peculiar national genius in creative research, that we approach problems from a diversity of viewpoints and of methods. This is a far surer way to success than single-minded, single-mastered research efforts, even when these are of considerably grander scale. And it is a less costly way, in the long run.

I shall also try to make some specific recommendations designed to further the interest of all regions of the country through the development of a sound national water policy.

WATER DEMAND PROBLEMS

Acute national problems of growing demand for water in an expanding economy face us in the years immediately ahead. For us in the semiarid "rain shadow" of the Rocky Mountains and throughout the Southwest, the problem is enormously intensified. Not only are we in a region of greater than average population growth, but we are in a region of greater than average rainfall fluctuation from an already marginal normal.

Many individuals and organizations have testified competently to this committee about the critical regional economic and social problems occasioned by the clear limitations and fluctuations of our ground and atmospheric water resources. The problem clearly affects regional economics in a drastic way and its solution will require farseeing national policy, lest crisis befall us suddenly when the next severe and sustained drought strikes a large region of the country.

Three main factors are increasing the water demands of the Southwest, and also, to a lesser degree, the whole Nation:

(1) The population is increasing rapidly, with corresponding growth of water usage;

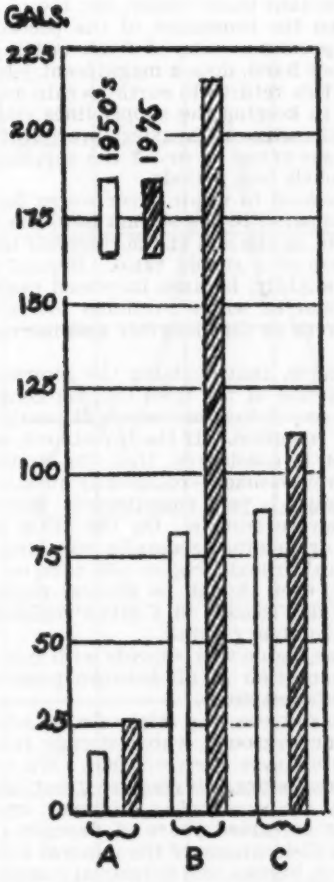
(2) Regional agricultural demands increase with population; and

(3) Industrial uses expand, at a rate that far exceeds the population increase.

The attached figures, from the Encyclopedia Britiannica Yearbook for 1957 details the expected demands. The increase in anticipated human and agricultural water use roughly parallels the population rise, while the industrial demand is expected to double, and to far outstrip the combined human and agricultural demands.

Arid lands are generally more variable in rainfall than regions of more abundant rain. In large areas of the Southwest, as in eastern Colorado for example, only 1 year out of 3 or 4 has rainfall sufficient for dryland farming. Practical limits have been reached in irrigation for such land use. Yet, beneficial cultivation of these lands is of great national value in good years, and will be increasingly so in years ahead. It is clearly evident that great benefits will result if it becomes possible to issue reliable year-in-advance forecasts of water reserves for these regions. The economic health of large regions of the Nation rises and falls with available water reserves that depend on yet unknown caprices of nature.

Moreover, in rare periods of abundance we tend to view the abnormally plentiful water reserves as a return to normal. We let ourselves be lulled into complacency that results in declarations of disaster when conditions of dry weather develop that are equally close to normal.



A - Direct Human Use
B - Industrial Use
C - Irrigation Use

Daily water consumption in the U.S. (in billions of gallons) in the 1950's, and the estimated figures for 1975.

From: Roscoe Fleming - "The Problem of Water", the 1957 Britannica Book of the Year (p. 8).

WATER SUPPLY CONSIDERATIONS

(a) The atmosphere is our real resource of fresh water

The atmosphere is man's real resource of fresh water. The oceans, of course, may ultimately become an important basic supply, but the problems of artificial distillation are formidable, and the economics of the processes now available are promising only where the premium value of fresh water justifies extremely high costs. Nature, on the other hand, does a magnificent job of distilling fresh water from the seas. Most of this returns to earth as rain and snow.

Where nature falls down is in keeping the supply lines clear. Moreover, she ignores our demand cycles. She gives us heaviest precipitation in the seasons when we least need it. And she turns on or off the supplies without advance warning, sometimes for disastrously long periods.

Dams and reservoirs can be used to retain river water for the future. The larger the reservoir volume compared to the stream flow, the larger its capacity to tide us over dry periods. But as the size of the reservoir increases, its ability to store water does not increase at a steady ratio. Beyond a certain size the storage ability increases only slightly, because increased evaporation and seepage gradually reduce the amount of water available for release downstream. These factors become more severe as the reservoir size increases, as Langbein[1] has shown.

Langbein estimates, for example, that doubling the reservoir capacity of the Colorado River with the completion of the Glen Canyon Dam will increase the water retention by 5 percent. Any future increase will result in only a fraction of a percent increase in useful retention. If the investment return from such a small increase in usable water is considered, then the desirability of further development of the Colorado River becomes economically questionable.

The weather and climate picture is very complicated. Some storms of a few hours duration can produce severe trouble. On the other hand, dry periods must be sustained for weeks or months, generally speaking, to be of drastic consequences. Sometimes a local drought region will turn up, with drastic consequences to those living in it, even though no general regional drought is in progress. Sometimes a severe dry season, in a given region, will occur in the center of a period of generally abundant rainfall.

Often a drought pattern in one region will coincide with rain in another; sometimes there is no apparent connection at all between persistent anomalies in different parts of the earth at different times.

Moreover, we have not yet solved even the fairly simple scientific problems of prediction of streamflow and underground water storage from known fluctuations of temperature and rainfall over a river basin. We do know, however, that river basins and underground storage layers are great integrators of short-term weather fluctuations. By the same token, however, systematic depletion of underground storage during sustained years of drought can take years to rebuild, and can result in gross dislocations of the mineral content of the stored water, with resulting agricultural, human, and industrial complications.

An interesting graph prepared by E. B. Kraus[2] of Australia shows the magnitude of the long-term abnormalities of rainfall that can occur at specific stations. It is shown simply as an example, with no implication that such a trend is worldwide, though Kraus has suggested that such may be the case. This graph shows rainfall between May and October at Honolulu, Hawaii. It indicates that from about 1880 to 1902 the rainfall in Honolulu (Hawaii) generally exceeded the average by about 25 percent. Thus at the end of the 22 years the cumulated excess rainfall was five times the average amount of rain that falls in a single season. Then a reversal set in, with comparably subnormal rainfall until about 1935. This wiped out the surplus, and piled up a cumulated deficit of almost twice a year's rainfall.

(b) Understanding the causes of the atmosphere's fluctuations

Droughts are produced by different causes in different parts of the world. In the central and southern Great Plains, for example, droughts develop when the high level winds are persistently strong in a west-east direction for a long period. Under these circumstances moisture-laden air of the Pacific is squeezed dry as it passes over the Rockies. Much of the moisture in this region is produced when warm, moist air from the Gulf of Mexico spills into the region and

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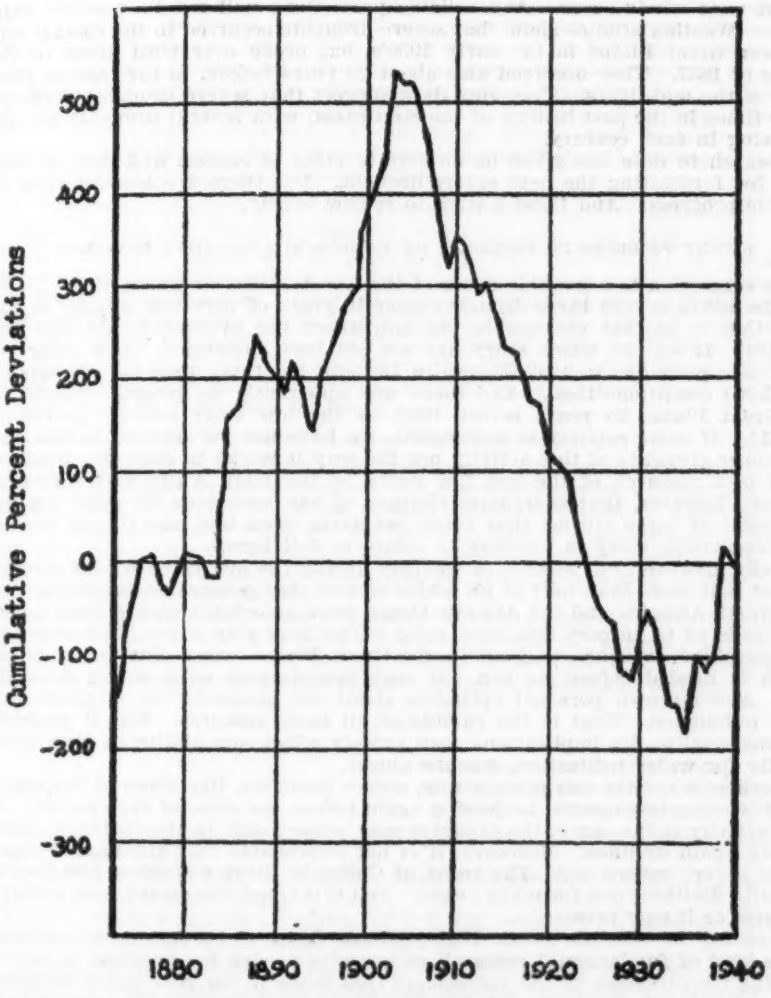
[1] W. Langbein, U.S.G.S. Circular No. 409, 1959.
[2] "Secular Changes of Tropical Rainfall Regimes," Quarterly Journal of the Royal Meteorological Society, vol. 81, p. 198, 1955.



Cumulative percentual deviations from summer (May-October) normal rainfall of 8.71 inches, Honolulu, Hawaii.

collides with cold polar air moving down from Canada. When the west winds are strong, collisions of these two air masses occur farther east, leaving broad regions of the Great Plains abnormally dry. By the same token, strong west winds bring abnormally wet weather west of the Continental Divide. The air is wrung dry as it rises over the mountains.

But the explanation is basically incomplete. We do not know why the persistent west winds occur. And reliable predictions will not be possible until we do. Weather studies show that severe droughts occurred in the central and southern Great Plains in the early 1950's, but broke over most areas in the spring of 1957. They occurred also about 20 years before, in the famous Dust Bowl of the mid-1930's. Tree ring data suggest that severe droughts occurred many times in the past history of the Southwest, with several droughts usually occurring in each century.

Research to date has given us no certain clues to causes, and thus no real basis for forecasting the next severe drought. But there are hopeful signs of possible progress. And these I wish to review briefly.

RECENT PROGRESS IN RESEARCH ON LARGE-SCALE WEATHER PATTERNS

One suggestion to a possible cause of the Great Plains droughts of the 1930's and the 1950's is that these droughts came in years of very low activity of the sun. Can it be that changes in the sun affect the average winds over the Rockies? If so, the whole story has not yet been unraveled. Low solar activity also prevailed in 1942–45 and in 1922–24, but there were no comparable dust bowl conditions then. And there was apparently no general drought in the Great Plains 20 years before 1933, in the low solar activity period of 1910–14. If solar activity is responsible, we have not yet learned to measure the proper elements of this activity nor the way it works to alter the weather.

Our own research of the last few years, at the High Altitude Observatory suggests, however, that short-term changes of sun emissions do affect the development of large storms that often penetrate deep into the United States. The fascinating story is too long to relate in full here.

Briefly, however, our studies of weather during the last three winter seasons suggest that more than half of all major storms that penetrated far southward over North America and the Atlantic Ocean were associated with a solar pulse. This leads us to suspect that such solar pulses may play a part in preventing long-sustained droughts, at least in the Great Plains area. But far more research is needed before we can put such speculations on a sound scientific base. And my own personal optimism about the prospects for progress may prove unfounded. That is the gamble of all basic research. But if progress does materialize, its implications may grossly affect our ability to plan more soundly for water utilization, seasons ahead.

Whether or not the sun plays a role, severe droughts, like those of the 1930's and 1950's can be expected to develop again before the close of the century. If solar activity is the cause, the droughts may occur again in the 1970's, as solar activity again declines. Moreover, it is not improbable that the next drought will be a very severe one. The trend of Colorado River waterflow has been a generally declining one for many years. And this trend downward may perhaps continue, or it may reverse.

I mention the research at the High Altitude Observatory only as an example of the kind of fundamental research so urgently needed for progress in understanding the processes of the atmosphere that make it our real water resource. This research is but one of many links in the chain of atmospheric sciences that must be forged. The key is new and imaginative basic research on a scale far greater than has been traditional in America to date.

Cosmic dust from outer space may also affect long period weather trends. Volcanic dust may do likewise. There are many tantalizing clues to follow. And there is also a need for much hard laboratory work, and extensive theoretical analysis by advanced mathematical techniques. Behind it all is the hope of vastly improved forecasting on long- and short-time scales. And if weather control is a realistic hope, this hope can only be realized when the present crude cloud-seeding operations are replaced by careful experiments, analyzed scientifically, and conducted on a cooperative basis over large regions and by many research groups. Man may someday learn to duplicate Nature's rainmaking processes or at least to find the means to speed or slow down the timing or alter the positioning of storms. If so, the benefits may extend to all corners of the globe, and may make possible far sounder national water usage policies for the future.

SPECIFIC RECOMMENDATIONS FOR FUTURE WATER POLICY

I have three specific recommendations to make, each of which has several aspects. They are as follows:

(1) More basic research must be done in the atmospheric sciences

Research into physical processes of the atmosphere, the fundamental fresh water resource of earth, must be vastly expanded in the years ahead. The promise of practically useful advances is great. The National Science Foundation has been charged with looking after the national interest in two major areas directly relevant to the problems of national water policy: (*a*) Research in atmospheric sciences in general, including questions like those discussed above; (*b*) research in weather modification. Funds must be made available to permit achievement of the realistic goals of the National Science Foundation in these two broad areas of national interest.

(2) Improved analytical and observational programs must be carried on

Agencies like the USGS, the Bureau of Reclamation, and State agencies must be encouraged to obtain and to analyze improved observations of the factors involved in rainfall, snowpack, evaporation, plant cover, and other factors involved in streamflow and natural underground water storage. I am happy to see research done with funds of the States, like those presently allocated to Colorado State University, University of Colorado, and the High Altitude Observatory, for studies of the flow from the Upper Colorado River Basin. It would further stimulate and broaden support of basic research at local levels if such funds were matched federally.

(3) Preparation for a great central and southwestern drought

We should now begin preparations of a sound national water policy, extending beyond limited regional confines, for a probable severe drought within the coming 25 to 50 years. The dates of such a drought cannot be firmly predicted on the basis of present research, but the examination of past statistics strongly suggests that there will be such a period before the end of this century. They have happened in the past several times per century, and this is therefore the likely prospect for the future.

To prepare, we should take cognizance that population growth is now very great in regions where the peril of severe drought is highest. This implies, particularly, that it is only sound judgment to deflect away from drought-prone areas those industrial developments that use large amounts of water.

HIGH ALTITUDE OBSERVATORY
OF THE UNIVERSITY OF COLORADO,
Boulder, Colo., December 2, 1959.

Memorandum to: Senator Robert S. Kerr, chairman, Senate Select Committee on Water Policy.

From: Walter Orr Roberts, director, High Altitude Observatory, University of Colorado, Boulder, Colo.

Subject: Brief summary of status of U.S.S.R. research on solar-weather relationships, and on long-range forecasting.

Senator KERR: During my testimony of November 20, 1959 you asked me to amplify certain questions regarding the relative status of the United States and U.S.S.R. in the kind of research that we do here at the high altitude observatory (on solar relationships to weather) and in the general questions of long-range weather forecasting. I am happy to amplify my comments in this memorandum.

I. SOLAR-WEATHER RESEARCH

Research on relationships of weather changes to changes of solar activity, here in the United States, has not been pursued, until the last 5 years or so, with the vigor it deserves. It does, however, have a long tradition. Much of the history has been discouraging because of the vagueness and uncertainty of the results achieved.

Many years ago, Dr. C. G. Abbot, of the Smithsonian Institution, undertook a long study of rainfall records over the United States as related to changes of the solar constant, which measures the sun's total heat received at the earth.

These studies were quite inconclusive. In fact it is not certain that the solar variations assumed to be exhibited in the solar constant data were in fact genuine solar fluctuations at all. During the 1920's, an extensive program of research was carried on by Clayton of the same institution. Clayton's work showed many interesting statistical effects, but developed no detailed theories, and no evidence for effects of large practical importance. Moreover, the results were all small statisical effects that showed up, somewhat inconclusively at that, in very large samples of weather data.

More recent work has been done by Duell & Duell, R. A. Craig, and R. Shapiro, and by the high altitude observatory group. The work of Shapiro, of the Air Force Cambridge Research Center, was the most important recent finding, and has broken ground for later advances. It also emphasized the importance of influences deriving from solar-charged particles connected with the aurora borealis. The research at the high altitude observatory follows up this same lead.

Research in the Soviet Union has been considerably more extensive. It is difficult to evaluate this research without spending many hours examining its strengths and weaknesses. However, I enclose a recent report by M. S. Eigenson, of the U.S.S.R., dealing with recent Soviet research in this subject. It is certainly clear that the number of serious research workers in the Soviet Union engaged in work on such subjects exceeds that here. And it is also clear that the Soviets have had the audacity to apply their findings to specific predictions of long-term and short-term trends in water resources (as mentioned on p. 8 of Eigenson's paper). The Russians have apparently been willing to forecast, based on expected solar activity trends, the course of climatology data expected up to the end of the 20th century.

My evaluation of this work is that it has promise, has not yet been unanimously accepted in the U.S.S.R., but has a growing acceptance there. On the other hand, a considerably larger number of workers appear to be engaged in study of solar and other cosmic influences on the weather than is the case here, although the viewpoint here seems also to be rapidly changing, which to us at high altitude observatory is a healthy sign. The Soviet workers engaged in these studies seem confident that significant advances are being made there and appear no longer to seriously dispute the fact that solar activity plays a role in climatic changes.

In this field it can be said that the Russians are ahead of us, at least so far as the questions of the number of competent scientists whose attention is being devoted to basic research in the subject. It is too soon to evaluate whether the Soviet findings are of good quality, and whether their optimism will be substantiated. My own personal conviction is that a very materially increased effort in these areas is desirable in the United States.

II. LONG RANGE WEATHER FORECASTING IN THE U.S.S.R.

We are very fortunate that excellent reviews of long-range forecasting research in the Soviet Union have been made by Baum and Thompson (published in the bulletin of American Meteorological Society, August 1959, pp. 394). These reviews show that a definite break in the planning of meteorological research in the U.S.S.R. took place in the mid-1950's, but it is apparently too soon to discern what practical implications this break may have had. The Russians do not appear to have applied, to the extent we have done in the United States, modern statistical approaches to the problem of weather forecasting. At least if such attempts have been made, they have been kept classified.

Moreover, there does not seem to be evidence that in this field the Soviets are ahead of us in basic theory. It is clear, however, that great importance is attached in the U.S.S.R. to research in meteorology. It is also true that a very strong self-criticism is in progress, and has affected the direction of much research there.

The review of Baum and Thompson asserts "that the examination of solar factors in long-range weather forecasting is achieving respectability in the U.S.S.R.," and mentions that Belinsky, of the Central Institute of Forecasting of the U.S.S.R., has published a book entirely devoted to the use of solar factors in long-range weather forecasting. It is highly unlikely that even most optimistic research people in the U.S. Weather Bureau would issue such a book. This means that we are either more wisely cautious, or somewhat behind them. It should be mentioned, however, that in certain other countries, such as Germany, solar-weather research is given considerably more attention than here as a means of approaching the problem of long-range forecasting.

Once again, however, it should be emphasized that there is no clear evidence that the Soviets have made any significant practical discovery in long-range forecasting that goes beyond our own knowledge.

III. RESEARCH ON WEATHER MODIFICATION

I do not have close familiarity with Soviet research on cloud physics or on modification. However, it is reported that the Soviets have been willing to gamble on the creating of a large inland sea with a principal goal of modifying the climate of substantial portions on the U.S.S.R. They have, of course, great incentive for efforts to increase the length of the growing season to improve wheat and other food production in the U.S.S.R.

I already mentioned in my testimony on the 20th of November, Soviet proposals to build a dam across the Bering Strait, cooperatively with the United States in an effort to modify the climate of parts of Siberia and Canada and Alaska.

On the questions of cloud physics research (which is closely related to questions of cloud seeding) we are fortunate, again, to have an excellent summary prepared by Dr. Louis Battan (published in the bulletin of the American Meteorological Society, September 1959, pp. 444).

It is clear from this that extensive studies of the formation of clouds, the role of atmospheric nuclei, the formation of water droplets, the formation of ice crystals, atmospheric electricity, and many related problems have received extensive attention in the U.S.S.R. Much of the Soviet literature is devoted to questions of cloud seeding and specifically to weather modification. However, in this field, and in particular in the question of evaluation of the results of cloud seeding, the Soviets do not seem to be so far advanced as we. According to Battan, "the Soviet literature does not reveal an appreciation of the difficulties in evaluation of seeding effects."

It is clear that the Soviet research in these fields is on a scale comparable with that in the United States. It is also evident that the Russian scientists are well informed about the research published in the other countries. On this point Battan states, "one can hardly say the same about American cloud physicists." This is partly a result of the fact that it is difficult for Americans to read Russian (and sometimes other foreign languages) while the translation services have in the past been better in Russian, and a far larger percentage of scientists read foreign languages. Happily the situation is improving in the United States, with vast expansions of the translation services available. It is unlikely that our knowledge of Soviet progress will lag in the future as it has in the past.

Battan recommends, however, that still greater improvements in translation services are necessary. Many important books on cloud physics are still not translated into English. To this I should add that the principal works on solar-weather relationships have also not been translated, and are unavailable unless one reads Russian.

It is clear that Americans are going to have to learn to read the Russian language to keep up in science, or we are going to have to continue and greatly expand the extremely expensive and time-consuming program of translation. At the present time it appears to be necessary to translate, over all areas of science, a volume of Russian publication that is very closely comparable with the total scientific output of the United States. Some institutions of higher learning, thus, are considering instituting a compulsory language requirement for advanced degree in the Russian language.

Battan estimates that in the general study of cloud physics and of basic meteorology the Russians are close to the same level as Western scientists, though in cloud seeding and weather modification there is an apparent lag in the Soviet work. However, Battan speculates that results of research in these areas may be classified.

IV. SPECIAL REMARKS ON MILITARY USE OF WEATHER MODIFICATION

I would like, finally, to emphasize again that I consider it highly improbable that advances in the science of weather modification will make possible any extensive use of "weather warfare." There is no indication today that it will be possible for man to modify the course of individual storms by extensive cloud seeding, or by other techniques. The possibility, however, cannot be completely ruled out. Therefore, the subject must be given intensive research; we cannot afford to be ignorant of something that might develop such large ultimate value. At the same time, studies of basic meteorology, of weather

modification, and of long-range forecasting either through the use of solar activity, cosmic phenomena, or strictly terrestrial factors has even stronger justification than "weather warfare." The military and peacetime uses of long-range forecasting, and the potential benefits in a peacetime economy of even modest increases in rainfall distribution or hail suppression even in restricted areas, more than justifies a vastly improved program of basic meteorological research.

Senator CARROLL. The next witness is Mr. Allen Brown, who is the vice president of the Colorado River Water Conservation District.

Is Mr. Brown present?

Mr. BROWN. Yes, sir.

Senator CARROLL. Mr. Brown, would you proceed, please?

STATEMENT OF A. ALLEN BROWN, VICE PRESIDENT, COLORADO RIVER CONSERVATION DISTRICT

Mr. BROWN. Members of the committee——

The CHAIRMAN. Is your name Brown?

Mr. BROWN. Allen Brown.

The CHAIRMAN. I have a statement here by Smith and Barnard. Are you to present their statement?

Mr. BROWN. I am presenting their statement in a modified form. If you will just throw that away, I will tell you what they say in there and then I will add some more to it.

The CHAIRMAN. Confidentially, should the committee make this statement a part of the record in addition to what you say?

Mr. BROWN. If you please, sir.

The CHAIRMAN. Fine.

Mr. BROWN. Yes, sir.

The CHAIRMAN. All right.

(The statement follows:)

STATEMENT OF COLORADO RIVER WATER CONSERVATION DISTRICT BY PHILIP P. SMITH, SECRETARY-ENGINEER, AND JOHN B. BARNARD, COUNSEL

This statement is submitted by the Colorado River Water Conservation District. The Colorado River Water Conservation District comprises the northwestern and west central parts of Colorado and encompasses within its boundaries approximately one-fourth of the area of the State. It is drained by the headwaters of the main stem of the Colorado River and its principal tributaries, including the Blue, Eagle, Roaring Fork, Gunnison, White, Yampa, and Little Snake Rivers. These western Colorado streams, along with the San Juan and Dolores drainages of southwestern Colorado, have contributed a long-term annual average of approximately 10,700,000 acre-feet, or 70 percent, of the undepleted flow of the Colorado River at Lee Ferry. This data is presented as background for statements hereinafter made.

Our statement was prepared on the premise that your committee is concerned with optimum use of the Nation's water resources, including present uses, as well as the future use of those water resources yet undeveloped. The Colorado River Water Conservation District was created by a statute enacted in 1937 by the General Assembly of the State of Colorado for the express purpose of conserving and promoting the development of the water resources of the district for beneficial uses. It is primarily concerned with the identical purposes as your committee, but, naturally, on a smaller or district level. In this statement it is our desire to acquaint you with our needs and plans for the optimum development of presently unused water resources in the natural basin of the Colorado River in Colorado. Based on this premise, we think you should be advised of the following facts:

First. During this year the State of Colorado observed what was termed its "centennial," which is, of course, the hundredth anniversary of the original

founding of the State. However, this was not the centennial year, as far as western Colorado is concerned. The greater part of the western portion of our State was included in Indian reservations and not open to settlement by white men until 1882. The economic development of western Colorado dates from that year, not from the year 1859. Agricultural and industrial development in eastern Colorado has, therefore, proceeded far in advance of that within our own area.

Second. Of the approximately 11 million acre-feet of water which originates in western Colorado, after giving effect to the Colorado River compact, the Upper Colorado River Basin compact, and the Treaty Between the United States and the Republic of Mexico, and, after deducting the water which is presently being utilized in the natural basin of the stream and that which is being exported beyond that basin by transmountain diversions to eastern Colorado, there remains to us for all of our future use no more than 1,250,000 acre-feet, or less than 12 percent of the Colorado River water which originates on our watersheds.

The details of how future development of our remaining water resources for irrigation and industrial uses are to be accomplished in western Colorado by means of at least 29 participating projects which are included in the Colorado River Storage Project and Participating Projects Act, and projects not contained in that act but planned for development by the Colorado River Water Conservation District, are being submitted to you, in tabular form, as an appendix to this statement. This appendix might be termed an overall picture of the present and future needs for water in the district and the outlook for western Colorado by the development of our remaining water resources.

This additional fact should be borne in mind by the committee. Located within the Colorado River Basin in western Colorado is the greatest storehouse of fuel energy in the world. We refer particularly to the oil shale deposits in the district which lie roughly between the White River on the north and the main stem of the Colorado River on the south, and also to some of the most extensive coal deposits in the United States located throughout most of western Colorado. The oil shale deposits noted, according to the U.S. Geological Survey, contain more than 1 trillion barrels of economically recoverable oil, or over four times the known petroleum reserves of the entire world. The Bituminous Coal Annual, published by the Bituminous Coal Institute of Washington, D.C., referring to the oil shale and coal reserves of western Colorado, states: "It is no wonder that fuel authorities in their moments of crystal gazing envision this region as the powerhouse—and perhaps the industrial center—of America's future." The development of these tremendous fuel energy resources is dependent, of necessity, upon the availability of a firm water supply which is completely adequate in every respect. That water supply must be derived from the million and a quarter acre-feet which remain to Colorado use from available runoff in the Colorado River system.

In our efforts to develop to the fullest possible extent the agricultural and industrial resources of our area, we are seriously handicapped by the insatiable demands by the city of Denver that Colorado River water be made available for municipal, industrial, and agricultural uses in eastern Colorado. The attention of the committee is here directed to this fact: In providing for the apportionment of the water of the Colorado River between the upper and lower basins in the Colorado River compact of 1922, the Colorado River Commission was assured by the official representative of Colorado on that commission that, because of physical barriers, not more than 310,000 acre-feet per annum of the water of the Colorado River could be taken, by transmountain diversions, to all of eastern Colorado. Contrary to this assurance, the amount of water so taken by accomplished and committed transmountain diversions now exceeds an average of 700,000 acre-feet per annum. The extent of exportation of Colorado River water from the natural basin of the stream to eastern Colorado in excess of 310,000 acre-feet per annum is the extent that agricultural and industrial development in western Colorado will be curtailed and precluded.

The district takes the position that it is no more that fair and just to contend that the lands within its boundaries, and the industrial potential within its area, are of right entitled to as full development as is possible, within the limits of our available water supply. We believe that we have just as much right to irrigate our lands, build up our cities, construct our industrial plants, and provide them with adequate water, as does the city of Denver or any area in eastern Colorado. So convinced, the activities of the district are directed toward that end. By all legal means we are engaging in establishing firm water rights to the use of this water. We have also given assistance, where

needed, to organize local conservancy districts which will act as contracting entities for participating projects. It is noteworthy that since enactment of the Colorado River Storage Project and Participating Projects Act seven conservancy districts have been organized within our district.

Where such has been possible, the district has attempted to coordinate its development with pressing needs for water in eastern Colorado, referring primarily to the proposed Fryingpan-Arkansas project, the completed Colorado-Big Thompson project, and Denver's Blue River diversions. However, if we are to be permitted to develop in western Colorado as we believe we are entitled to develop, no further exportations can be made from the natural basin of the Colorado River in Colorado. In saying this, we are, of course, actuated by what may be termed "self-interest" or "selfish interest." However, we want to express to this committee that the time may well come when the safety of the United States, as a free nation, may well depend upon the availability for use of the astronomical quantities of fuel energy locked up in the oil shale and coal reserves of western Colorado, which cannot be developed without water.

When we emphasize the need for water for the development of the oil shale industry, we realize that, comparatively speaking, the amount required in the industry itself is far less than will be needed for municipal purposes to supply the urban areas which will come into existence for the purpose of operating the oil shale industry facilities. Furthermore, we should not be misunderstood as contending that the oil shale industry is the only one which may well be developed in western Colorado. Our abundance of coal, nonferrous metals, pulpwood, and other resources will require water for their development.

Officials of the district have recently been contacted by officials of the Department of Naval Petroleum and Oil Shale Reserves of the U.S. Navy with regard to the establishment of rights to the use of water required for the development of the naval oil shale reserves and other oil shale deposits within the district, and, by the way, you may be interested to know that approximately 50 percent of these oil shale reserves are held in Federal ownership. We agree with these naval officials that it is essential that a decreed amount of water, which, in the very nature of things, must be primarily stored water, be earmarked for development of the naval and other federally owned oil shale deposits in western Colorado. "Earmarked" and "reserved" water cannot be accomplished under Colorado water law unless accompanied by present use or intended use within a reasonable time in the future. However, we believe it to be very important that, in planning for future water resources development within the district, the plans should include development of water for the oil shale industry. We are convinced that water resources development plans for western Colorado must comprehend and provide for municipal and industrial water to facilitate the use of our oil shale resources, especially those of the U.S. Navy, in order that when those reserves are needed their availability will be assured.

With this in mind, we have made plans for some storage development not comprehended in the Bureau of Reclamation reports for water resources development in western Colorado. In addition to those developments made possible by and specifically named in the Colorado River Storage Project and Participating Projects Act, in arranging our settlement with eastern Colorado for the Fryingpan-Arkansas project, we insisted that maximum storage be provided in the Ruedi Reservoir site to insure a part of the future water requirements for our potential industrial and agricultural growth. We furthermore have made statutory filings for and are seeking conditional decrees for storage reservoirs in the Eagle River Basin and on the main stem of the Colorado River.

The Colorado River Water Conservation District, particularly since the enactment of the Colorado River Storage Project and Participating Projects Act, has directed its entire energy, within the limits of its financial resources, to the end of devising the best and most efficient means of guaranteeing a water supply for its future industrial and agricultural development. An essential part of that activity has been and must continue to be presenting the best and strongest opposition to the further depletion of water remaining to us which others seek to bring about by exportation from the natural basin of the Colorado River in Colorado. The apportionment of water at Lee Ferry was predicated, at least in substantial part, on the representation made by Colorado representatives in framing the Colorado River compact relative to exportation from the natural basin to eastern Colorado, which provided for less than half of the amount now committed for such exportation.

Western Colorado is duly appreciative of the reclamation development through Federal efforts of land and water resources within the district. We are proud

of the Uncompahgre, Grand Valley, and Fruitgrowers projects, which have demonstrated the worth of reclamation development in western Colorado. These projects have made a major contribution to our present development. We are looking forward to completion of the Collbran, Paonia, and Smith Fork projects, now under construction within the district by the Bureau of Reclamation. The district is also highly appreciative of the passage by Congress and approval by the President of the Colorado River Storage Project and Participating Projects Act, which offers us such a great opportunity for future development.

We wish to thank the committee for this opportunity to present our problems, thoughts, and desires with respect to needed water resources development in western Colorado.

We direct your attention to the appendix attached to this statement, which presents specific data on the potential development within our district which could mean so much to our future.

APPENDIX

Planned water resources development in the Colorado River Water Conservation District

Project name	Bureau of Reclamation planning status	Water rights status	Sponsoring entity [1]	Project purpose	Project lands in acres	Consumptive use of water in acre-feet [2]	Direct expenditures by district and local interests [3]
Ashcroft	Programed	Statutory filing made.	Under study	Domestic, municipal, irrigation, industrial, power.	3,000	3,000	$1,200
Basalt (Cattle Creek and Ruedi Reservoirs)	Authorizing report partially completed.	Decree granted	do	Domestic, municipal, irrigation, industrial, flood control.	21,000	20,000	10,200
Battlement Mesa	Reconnaissance report.		do	Domestic, irrigation.	6,800	10,700	800
Bluestone	do	Decree pending	None to date	Domestic, irrigation, industrial, power.	10,900	20,000	2,600
Bostwick Park	Authorizing report completed.	do	Organized	Domestic, irrigation, municipal.	6,900	4,000	3,300
Cochetops	Reconnaissance report.	do	do	Domestic, irrigation.	19,500	16,000	3,200
Curecanti	Authorized	do	do	Domestic, irrigation, municipal, industrial, power, flood control, river regulation.	130,000	140,000	6,000
Dallas Creek	Authorizing report in preparation.	do	do	Domestic, irrigation, municipal, industrial, power, flood control.	22,000	18,000	4,000
Eagle Divide	Reconnaissance report.	Statutory filing made.	None to date	Domestic irrigation, power.	10,900	12,000	2,200
East River	do	Decree pending	Organized	Domestic irrigation.	2,750	2,000	2,000
Fruitgrowers extension	Authorizing report completed.		do	do	3,600	5,500	2,500
Fruitland Mesa	Authorizing report in preparation.	Decree pending	Under study	do	19,400	15,000	2,600
Grand Mesa	Reconnaissance report.		Being organized	do	25,300	20,000	500
Great Northern	do		Under study	do	8,100	13,500	200
Gore power	do	Statutory filing made.	Organized	Domestic, irrigation, municipal, industrial, power, river regulation	60,000	55,000	2,200

				power, river regulation.			
Gypsum (Eagle Valley)	do	do	Under study	Domestic, irrigation, municipal, industrial.	11,500	8,000	2,400
Hayden Mesa	do		do	Domestic, irrigation.	22,900	32,200	400
Juniper	Authorizing report in preparation.	Decree pending	do	Domestic, irrigation, municipal, industrial, power, river regulation.	33,000	50,000	8,100
Ohio Creek	Reconnaissance report.	do	Organized	Domestic, irrigation.	20,000	14,000	2,400
Parshall	do	Decree granted	do	do	27,500	28,600	4,000
Rabbit Ear	do	Decree pending	do	do	19,200	16,400	3,800
Red Cliff		Statutory filing made.	Under study	Domestic, irrigation, municipal, industrial, power.	10,900	50,000	10,900
Savery-Pot Hook	Authorizing report completed.	Decree pending	Organized	Domestic, irrigation, municipal.	35,800	43,400	7,400
Silt	Authorized		do	Domestic, irrigation.	7,300	5,200	4,800
Tomichi	Reconnaissance report.	Decree pending	do	do	27,600	13,000	3,400
Troublesome	do	do	do	do	13,600	13,000	3,600
Wessels	do	Statutory filing made.	Being organized	Domestic, irrigation, municipal, industrial, power, flood control.	6,800	7,400	4,500
West Divide	Authorizing report in preparation.	Decree granted	Under study	do	65,600	88,100	6,400
Yellow Jacket	Reconnaissance report.	Filing studies in progress.	Organized	Domestic, irrigation, industrial.	41,100	53,800	3,800
Total						777,800	109,400

[1] Local water conservancy districts meeting requirements of the Colorado River Storage Project and Participating Projects Act.

[2] Net depletion to 1,250,000 acre-feet of water remaining to Colorado in compacted share of Colorado River water.

[3] Direct expenditures of Colorado River Water Conservation District and local interests for project studies, establishment of water rights, and assisting with organization of local water conservancy districts. Since organization in 1937, the Colorado River Water Conservation District has expended its entire revenues for planning, promoting, and conserving water for potential water resources development within the district. These expenditures from 1937 to Oct. 31, 1959, have amounted to $453,800.

Oil shale interests, including Union Oil of California, Dow Chemical Co., Sinclair Oil Co., and Standard Oil of California, have obtained decrees to the use of more than 1,000 second-feet of direct flow water in the Colorado River in the Rifle-DeBeque area to provide for a total consumptive use of direct flow water amounting to some 200,000 acre-feet per annum. Storage to be provided by some of projects included in tabulation above will firm up a consumptive use demand by the oil shale industry amounting to 300,000 acre-feet per annum. This added 200,000 acre-feet of direct flow water would make a total demand for increased consumptive use of Colorado River water within the Colorado River Water Conservation District of 977,800 acre-feet per annum, which would leave only 272,200 acre-feet from the 1,250,000 acre-feet of Colorado's unused share in the Colorado River to satisfy the future in basin water requirements for development in the San Juan and Dolores River Basins. The Bureau of Reclamation has made plans for 3 projects in that area; namely, the Animas LaPlatta, Dolores, and the San Miguel projects, which have a combined consumptive use requirement of 212,200 acre-feet annually, leaving only 60,000 acre-feet for additional development in the San Juan and Dolores Basins or for presently unplanned uses in the Colorado River Water Conservation District area.

Mr. BROWN. Gentlemen, I am a native-born western Coloradan. I want to state briefly what our district is, some of the national importance of our area, briefly some of the problems that we have in common with the Federal Government in our area. Our No. 1 problem is the city and county of Denver. Our No. 2 problem is the Secretary of the Interior.

I want to comment briefly on the Fryingpan project, not as a problem but as a method of solving problems.

And briefly Curecanti Reservoir which is in our area and immediately above the confluence of the Gunnison River and the Uncompahgre River where I live, and briefly certain conclusions. I promise you I will be through within the time allotted.

This district comprises 12½ counties in the west and northwest portion of the State, encompassing approximately one-fourth of the area of the State.

It is drained by the main stem of the Colorado River, including the Blue, Eagle, Roaring Fork, Gunnison, White, Yampa, Little Snake, and Uncompahgre Rivers.

This area along with the San Juan and Dolores drainages in southwestern Colorado contributes an average, and I underline that average, of 10,700,000 acre-feet, or 70 percent of undepleted flow of the Colorado River at Lee Ferry. That is the dividing line between the upper and lower basin.

This district was organized under a 1937 statute and this area has been developed since the Indians left in 1882, the Ute Indians, that is.

We have not been in existence since 1858 as has the eastern portion of the State and naturally we are a little backward. But I think we are gaining. I want to say that after taking care of commitments made under the 1922 Colorado River compact, the 1948 Upper Colorado River compact, and the treaty between the United States and Mexico and the present uses of water in the natural basin, there remains for Colorado no more than 1,250,000 acre-feet, or less than 12 percent of the Colorado River water which originates in our watersheds for use in Colorado.

The CHAIRMAN. Let me understand that now. You say that that is the total that will be available to Colorado or that is the total of the uncommitted part which belongs to Colorado?

Mr. BROWN. That is the total of the uncommitted part.

The CHAIRMAN. I see. All right.

Mr. BROWN. That is important because of the project authorized by Congress.

The CHAIRMAN. Yes.

Mr. BROWN. Attached to the written statement, which has been handed to you, you will find a list of projects, including Curecanti holdover storage reservoir and 28 participating projects which are included in the Colorado River and Participating Projects Act, and which are necessary for the present and future needs of water in this district.

You will note that the total consumptive use of the water set up for those projects comes to 777,800 acre-feet per year.

I am going to mention another 400,000 acre-feet in a moment, which will demonstrate to you that practically all of this uncalled water is committed.

I say this because of the national importance of this area.

I wish to call your attention to the fact that the Colorado River Basin in western Colorado is the greatest storehouse of fuel energy in the world. Our oil shale deposits are located between the White River on the north and extend to the main stem of the Colorado River on the south.

The CHAIRMAN. What part of the known shale oil deposits are in Colorado, all of them?

Mr. BROWN. You mean in the West?

The CHAIRMAN. In the area to which you refer. It is a continuing area, as I understand.

Mr. BROWN. It is my understanding that all of the oil shale deposits that are in Colorado are located in western Colorado.

The CHAIRMAN. I understand that. I know that all of them that are in Colorado are located in Colorado. What I am asking is if you know what part of the known reserves in that general area are in Colorado? Are any in any adjoining State?

Mr. BROWN. They extend into eastern Utah, as I understand and I think some into southern Wyoming; is that correct, Mr. Kuper?

Senator CARROLL. I think they call this the Mahoney Ledge. I think it extends into Wyoming and into Utah but the greater portion of it is in Colorado.

Mr. KUPER. Senator, approximately 80 percent of the oil shale is in Colorado.

Senator CARROLL. Is that right, they call that the O'Mahoney?

Mr. KUPER. The Mahoney.

Senator CARROLL. I tried to give it a little flavor.

The CHAIRMAN. You tried to render unto O'Mahoney the things that were not O'Mahoney's.

Mr. BROWN. I want to bring this point to you: 50 percent of these deposits are owned by the Department of the Naval Petroleum and Oil Shale Reserves of the U.S. Navy. The area contains more than 1 trillion barrels of economically recoverable oil or over four times the known petroleum reserves of the entire world. I think Mr. Sparks put that at three times the reserves of the entire world but we say four.

The CHAIRMAN. Neither of us will ever live long enough to prove which of you is right but I am happy to have both estimates.

Mr. BROWN. Thank you, sir.

The area is underlaid with vast coal reserves.

The Bituminous Coal Annual published by the Bituminous Coal Institute of Washington, D.C., referring to these reserves states:

> It is no wonder that fuel authorities in their moments of crystal gazing envision this region as the powerhouse, and perhaps the industrial center, of America's future.

A firm water supply, completely adequate in every respect is necessary for the development of these tremendous resources—not only the processing of resources themselves, but to service the population which will come into existence for the purpose of operating the oil shale and coal industry facilities.

The time may well come when the safety of the United States as a free nation may well depend upon the availability for use of the astronomical quantities of fuel energy locked up in the oil shale and coal reserves in western Colorado.

Officials of the district have recently been contacted by officials of the Department of Naval Petroleum and Oil Shale Reserves of the U.S. Navy in regard to the establishment of rights to the use of water required in the development of the naval oil shale reserves.

The oil companies have been giving close attention to these questions, and have been expending considerable funds on this problem also.

I want to state briefly four problems which do exist and I think should be considered by the Federal Government.

First, the insatiable demands of the city of Denver for water from the headwaters of the Colorado River.

I mention this not because the problem cannot be solved; I say this because unless we discuss our problems, they cannot be solved, and to illustrate what is happening.

The Williams Fork Reservoir, which is located on the Williams River, a tributary of the Colorado River, above the town of Granby and Crimley, was constructed by Denver, originally to replace diversions of water from the Fraser and Williams Rivers, which diversions are taken from the Jones tunnel in the amount of about 21,000 acre-feet per year.

You understand when you try to store the water during the flood season and then when these tunnels are diverting natural flow from the Fraser River or Williams River, then a like amount of water is released from the reservoir. That is the theory of replacement water.

Until recently that reservoir would store about 6,000 acre-feet. Within the last 2 years it has been raised to 9,300 acre-feet and claim made for new uses. There is a claim for 9,300 acre-feet as replacement water for those two diversions. But I want to point out to you the new uses that are now being proposed for that reservoir.

One new use is to use it as replacement water for water to be diverted through the Roberts Tunnel on the Blue River, which will be between 15 and 20 years from now.

A second new use is also for the present operation of a powerplant which incidentally is being operated without a license from the Federal Power Commission and under a contract with the public service companies of Colorado.

If this reservoir is granted the decree requested by Denver dating—if that decree can be dated back to 1935, the result will be that two of the important projects of the Bureau of Reclamation, the Parshall project, and the Troublesome projects will be killed. There is not sufficient water in that area for both.

If the Williams Fork Reservoir was limited to approximately 31,000 acre-feet there would be sufficient water for both of these projects and to permit the Williams Fork to be used for replacement purposes for the Jones and Moffat Tunnel diversions——

Senator MARTIN. It can amount to what?

Mr. BROWN. 31,000.

Senator MARTIN. 31,000?

Mr. BROWN. 31,000 without any injury to those proposed projects.

The operation of this powerplant that has recently been installed has an injurious effect in that they release water for about 5 hours per day. This causes extensive fluctuations in flow which injuriously affects the diversion of water for irrigation purposes.

I will mention that again in connection with the Secretary of the Interior problem.

While Denver at the present time has actual use of 180,000 acre-feet of water per year and has obtained conditional decrees for an additional 177,000 acre-feet from the Blue River diversion, they are now doing two things which injuriously affect our district and the Federal interest there.

(1) They are now claiming all of the waters on Homestake Creek on the headwaters of the Eagle River and reaching out for water in the Piney River.

(2) Demanding that reserve water in the Green Mountain Reservoir, which is part of the Big Thompson project set up for future development in western Colorado, be released as replacement water for water to be diverted from the Blue River 15 to 20 years from this time.

We suggest that the U.S. Navy should not only take a look at this water but should also make funds available to aid in the development of water for industrial resources in connection with Navy oil shale.

Our experience in water matters has led us to believe that our future development depends upon storage of water as contemplated for by the Participating Projects Act. We recommend that Denver should adopt a program of storage of floodwaters instead of attempting to put all of the water in this party of the United States under decretal obligation to the city. The Lord has not given us an inexhaustible supply of water, nor will there ever be sufficient for such a wasteful method of use as has been and is now being followed by the city of Denver, of direct flow for use as has now been. They have a very modest reservoir program that should be greatly enlarged rather than attempting to continually increase their demands on natural flow of water which in many years is not available in western Colorado. As was stated here not too long ago the average flow of the Colorado River is determined somewhere between 6 million acre-feet per year to the lower basin and as high as 20 million.

No sound water resource can depend upon a source of supply which fluctuates that much from year to year.

Our second problem is mentioned as the Secretary of the Interior.

As you know, Senate Document No. 80, establishing the principles of administration of water in connection with the Big Thompson transmountain diversion project was adopted many years ago, and among other things, specifies certain duties to be performed by the Secretary of the Interior to protect the decreed water rights and the future development of water rights in western Colorado.

Since the Big Thompson has reached practically full development, our water users have been injuriously affected by the manner in which water has been released by Government officials at Granby and the Granby Reservoir, the Willow Reservoir and Shadow Mountain in great fluctuations varying from 40 cubic feet per second to as high as 200 cubic feet per second within the same day.

Irrigation headgates and diversion structures are being washed out or filled with sand and gravel to the extent that it has been found necessary to file suit in the State court against the Secretary of the Interior in June of this year. That case has now been removed by the Secretary to the Federal court.

We submit this, that if the Secretary of the Interior and engineering would make half as much effort to determine the cost of the trouble in and the remedy as he is in preparing to defend this suit, the matter could be remedied by the use of a little commonsense and less legal technicalities. And I have been in the law business for 28 years.

This is important not only because of this particular project, but that all of the future transmountain diversion to date including the proposed Frying Pan have adopted the conditions contained in Senate Document No. 80 and we feel that the Government should honor its contracts. Our Federal court, the Honorable J. Lee Nounce, has ruled that Senate Document No. 80 is a contract.

I want to mention the Fryingpan-Arkansas project in this way.

We believe that the agreement which has been reached by all of the interested areas on this project under the able leadership of Governor McNichols and our water director, Mr. Sparks, represents what could be done by reasonable minds working for the benefit of the State and the Nation. During this past year, certain adjustments have been made by the western and eastern slope interests which permit greatly increased storage of water in western Colorado in the Ruedi and other reservoir projects by the expenditure of approximately the same amount of money and at the same time permit the diversion of water to eastern Colorado that has been explained as an average of 69,000 acre-feet per year.

In this connection, we also wish to call your attention to the fact that when the Colorado River Compact of 1922 was entered into, Colorado was assured that because of physical barriers not more than 310,000 acre-feet of water per annum of the Colorado River could be taken by transmountain diversion to all of eastern Colorado. At the present time, the water so taken by accomplished and committed transmountain diversion now exceeds an average of 700,000 acre-feet per annum. The extent of exportation of Colorado River water from the natural basin to eastern Colorado in excess of 310,000 acre-feet, which is approximately 400,000 acre-feet, is the extent that agricultural and industrial development in western Colorado will be curtailed and precluded.

In the statement which you have I mention to Senator Kerr and Senator Carroll there is a table showing 29 projects listed. It is in that green-backed cover.

In the back there is a table which shows a consumptive need of 770,000, almost 778,000, acre-feet of consumptively used water will be required for the projects proposed under the Participating Projects Act. When added to this 401,000 acre-feet it shows that practically all of our water has been exhausted or will be exhausted when those uses come in.

It is therefore our opinion that no further exportations can be made from the natural basin of the Colorado River within this State.

Briefly, the Curecanti project, which is located in our district, is the only holdover storage project that will directly benefit the State of Colorado. There are some who prefer that it not be built and who would resort to sentiment or other illogical reason to prevent such construction. Be not misled by those who complain that this project will eliminate the harvest of 1,500 animals per annum in the area. This number includes the 1,050 cottontail rabbits, 275 sage hens, 250

mule deer, 125 muskrats, 15 mink, and I forgot there are 13 other animals which the Bureau of Sport Facilities and Wildlife in the September 1957 report, table 7, page 23, submits as sufficient to turn down the Curecanti Reservoir.

May we also advise you that the major portion of the Gunnison River itself in this area is now posted or restricted as to fishing. Also, be not misled by those who have or are now planning to receive the benefits of low elevation storage in desert areas, where evaporation loss is high, and who would now warn you about evaporation losses of stored water in the high elevations of Colorado, where such losses are practically nil or nonexistent, or I would say very low percentage-wise as compared with some of the major projects in the desert areas.

In connection with this project, it has been stated here by Mr. Sparks, our State water director, that over $3 million has been allocated to this reservoir as recreational benefits which will be received by the construction of the same.

In conclusion, let me state that this district has attempted to coordinate its development for pressing needs for water in western Colorado, referring primarily to the proposed Fryingpan-Arkansas project, the completed Colorado-Big Thompson project, and Denver's Blue River diversions. We are appreciative of the reclamation development through Federal development of land and water resources within the district. We are proud of the Uncompahgre, the Grand Valley, and the Fruit Growers Reservoir projects, which have demonstrated the worth of reclamation development in western Colorado and I might say in the Nation. These projects have made a major contribution to our present development and to taxes paid to the Federal Government and local governments.

We are looking forward to completion of the Collbran, the Paonia, and the Smith Fork projects now under construction in the district by the Bureau of Reclamation.

Our present big objective is Curecanti Reservoir.

We wish to express our appreciation for the passage of the Colorado River Storage Project and Participating Projects Act by Congress and the approval of the same by the President. Without it, our future development would be impossible.

We wish to thank the committee for this opportunity to present our problems, thoughts and desires with respect to the needed water resources development in western Colorado.

We again call your attention to the statement and the appendix of projects which we are filing with your committee.

Thank you very much.

Senator MARTIN. A very good statement. We appreciate having it in our record.

The next witness scheduled is Mr. William S. Eakes, counsel for the Southwestern Colorado Water Conservation District.

STATEMENT OF WILLIAM S. EAKES, COUNSEL FOR THE SOUTHWESTERN COLORADO WATER CONSERVATION DISTRICT

Mr. EAKES. Senator Martin, ladies and gentlemen: The area under study in this report is that portion of southwestern Colorado within the drainage basin of the San Juan River and its tributaries in Colorado, and the drainage basin of the Dolores River and its tribu-

taries in Colorado. The San Juan River and the Dolores River are two of the principal tributaries of the Colorado River system.

The area is characterized as a dissected plateau with elevation ranging between 5,000 and over 13,000 feet, with an average elevation of approximately 6,500 feet above sea level. The La Plata Mountains, the San Miguel Mountains and the San Juan Mountains are located within the area and provide the headwaters for over a fourth of the water of the Colorado River system.

Southwestern Colorado was first developed as a mining community. Large deposits of the metallic minerals still remain undeveloped in this area. More recently, uranium production has made itself felt. One of the largest uranium mills in the Nation is located at Durango. The oil and gas resources in the area are now in the process of intensive development. Most of the major oil and gas companies of the Nation maintain active offices in the area. The four corners oil and gas field has been described by authoritative sources as having the largest reserves of any field in the United States.

The entire area of southwestern Colorado is underlined with coal. In his survey of coal resources of the United States, M. R. Campbell estimated the enormous reserves of coal as amounting to 28,900 million tons of medium to high volatile bituminous coal of which large parts can be manufactured into coking coal. Many of the coal-mining sites can be strip mined.

To take advantage of these tremendous resources, plans are now being completed to construct in the four-corner area near Shiprock in New Mexico a large electricity powerplant. This plant will produce, so I have been advised, more power than will be generated at Glen Canyon Dam. It undoubtedly will be utilized to develop a petrochemical industry from the coal and petroleum reserves in the area.

The population of southwestern Colorado and the four-corners area in general has been increasing at a rapid rate since the beginning of the century. In the last decade, this growth has reached "boom" proportions. The scenic splendors, the year-around pleasant climate, the natural recreation facilities and the promising economic opportunities are attracting a rapidly increasing number of people to the area.

I have not mentioned in my report other of the natural resources that are available located in southwestern Colorado, one in La Plata County and one in Archuleta County, where there are two of the largest lumber mills in the Rocky Mountain area.

The agricultural development in the area, I have not gone into it. It is available in other sources.

Southwestern Colorado now has two small reclamation projects already in operation. The Pine River project with its Vallecito Reservoir and the Mancos River project with its Jackson Gulch Reservoir. With these projects, by direct diversion and by privately financed projects, over 175,000 acres or irrigable land are now irrigated in southwestern Colorado. However, there are almost 200,000 acres of class 1 and 2 irrigable land not now irrigated. In addition to this, there are over 400,000 acres of class 4 irrigable land not now irrigated. These figures are based on the Preston survey of the U.S. Bureau of

Reclamation as analyzed by the Hill report to the Colorado Water Conservation Board.

The development of this tremendous potential for economic expansion in this magnificent area is almost entirely dependent upon the most effective use of the available supplies of water.

Southwestern Colorado now has four projects presently under investigation or ready for construction. These projects are as follows:

The Florida project: This project has already been authorized as a participating project of the Colorado River storage project. The Lemon Reservoir on the Florida River in La Plata County, Colo., will increase the irrigation supply for 13,728 acres of land and provide a new full irrigation supply for 5,730 acres. It is anticipated that the Florida project will cost approximately $11 million. Its construction is most urgently needed, and urged. The investigations have been completed and the construction planning has reached a stage that is now ready for construction.

The Dolores project: This project contemplates the construction of a reservoir and irrigation system on the Dolores River in Dolores County, Colo. It is anticipated that it will furnish a supplemental water supply to 9,450 acres of land and full water supply to 56,500 acres of land. The cost of the project has been estimated to be $26 million. However, this estimate is several years old.

The Animas-La Plata project: This project contemplates the construction of a reservoir on the Animas River above Durango, Colo., and the diversion of water to the La Plata River where it will be used to furnish a full new irrigation supply to 45,920 acres and a supplemental supply to 20,100 acres of land in La Plata County, Colo., and a full new irrigation supply for 15,060 acres and a supplemental supply for 5,540 acres of land in New Mexico. The cost of this project has been estimated at $80 million. However, this estimate is several years old and may be out of date.

The San Miguel project: This project contemplates a reservoir on the San Miguel River downstream from Telluride, Colo. It will furnish a full new irrigation water supply for 33,000 acres of new land and a supplemental water supply for over 10,000 additional acres of land in San Miguel and Montrose Counties. The cost of this project has been estimated at $43 million. However, this estimate is now several years old.

The projects are all of such magnitude that it is impossible for them to be constructed by local financing. These are the types of projects in which the U.S. Government can well make an investment in the future of this country. In order for southwestern Colorado to receive its fair share of the water supply available and to realize its potential development, it is urgently necessary that these projects receive the prompt and favorable consideration to which they are entitled.

Conflicts are developing over the division of the available water supply. It is feared by some that a proposed diversion to New Mexico from the headwaters of the San Juan River may interfere with the development of the needed projects in Colorado. This problem is presently under investigation by the States of Colorado and New Mexico, and it is hoped that a solution will be forthcoming.

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This committee can perform a valuable service by insisting that reclamation development be on a basinwide plan, giving priority to the project with the highest benefit-cost ratio, and not merely on a "first come, first served" basis. This type planning should be done on each of the major tributaries of the Colorado River. The result should be a fair and equitable apportionment of our meager water supply.

Feasibility investigations of projects in western Colorado has been drastically delayed by the fact that the amount of money made available for project investigations has fluctuated from year to year over the past 10 years. This very fact of fluctuation from year to year has produced an uneconomical and inefficient operation in the Bureau of Reclamation. This past year, due to a considerable reduction in investigation funds available to the Durango office of the Bureau of Reclamation, almost half of the personnel of that office was transferred or laid off. A similar situation occurred in the Grand Junction office of the Bureau. This was explained as to the Durango office by the fact that some of the investigations had been terminated. However, almost simultaneously, it was announced that the date for the completion of the current investigations had been delayed for another year. The hiring and firing of employees, with its wasteful but necessary retraining of new employees, produces an inefficient situation which is inexcusable, but seems to go on from year to year.

In addition, the actual amount of money appropriated for general investigations has decreased over the past 10 years even though it is well known that because of inflation and other increased costs of operation, the buying power of the dollar has decreased.

In order to preserve the heritage of our future generations, Congress must do all in its power to increase the water supplies available through scientific and technical investigations such as desalination and weather control. Also, and equally important, it must promote the most effective use of the available supplies of water through the planned development and control of our rivers.

Time is of the essence in water development in southeastern Colorado. If the investigations are not completed and the projects constructed promptly, the available water supply will be exhausted by use elsewhere and the potential development of southwestern Colorado will be stymied.

I might add to the statement, if you please, Senator Martin, the problem is accentuated in the San Juan Basin.

The San Juan River, the main stem has the tributaries of the Animas River and Durango and the Pine River on which some development had been made, the Florida River and the Piedra River and other rivers flowing into it. There is a natural water scarcity in the area. And what water we have had has been divided up between the upper and lower States of the Colorado River compact and then redivided by the Upper Colorado River Basin compact, of which Colorado receives 51¾ percent and New Mexico receives 1¼ percent.

New Mexico's 1¼ percent is taken entirely from the San Juan drainage area leaving the burden of the 1¼ of the entire flow of river upon that one source.

Now there have been recorded years where 1¼ percent of the Colorado River which is New Mexico's share is more than the entire flow of the San Juan River.

Somehow that has to be regulated and controlled to the point where the development both in New Mexico and Colorado can for forward equitably.

Senator MARTIN. It is your point that the flat percentage allocation does not fit the highly variable natural conditions?

Mr. EAKES. Yes, sir; that is very true.

I think that was unfortunate but it is there. We have to live with it. But by proper control, by proper storage and regulation of the flow of the rivers I think the problem can be solved where both areas in the San Juan Basin, both in Colorado and New Mexico have their development.

Senator MARTIN. That control that you think is included in the proposals, you have included in your statement?

Mr. EAKES. Yes, sir. The only one of the projects that I mentioned that is involved in this situation is the Animas-La Plata project. New Mexico has proposed and has now ready for authorization two projects which I might add are the result of solution of their intrastate water problems. The San Juan-Calmandi diversion from the upper reaches of the San Juan River and the Navaho project in the Farmington area of which the navigable dam is now in construction.

Senator MARTIN. Your statement was very welcome to this committee and it will be very helpful to us. Thank you.

Mr. EAKES. Thank you. You are welcome.

Senator MARTIN. The next witness is Mr. Charles Boustead, executive secretary of the Southeastern Colorado Water Conservancy District.

STATEMENT OF CHARLES BOUSTEAD, EXECUTIVE SECRETARY, SOUTHEASTERN COLORADO WATER CONSERVANCY DISTRICT

Mr. BOUSTEAD. Senator Martin, ladies and gentlemen, my name is Charles Boustead and I am executive secretary of the Southeastern Colorado Water Conservancy District.

This district was formed under the pertinent Colorado statutes in April 1958, and comprises all of the irrigated area of the Arkansas Valley above John Martin Dam and below Leadville, a distance of approximately 250 miles. It represents portions of nine counties with an estimated population of 350,000 people, including the two large cities of Colorado Springs and Pueblo. The district has an assessed valuation of approximately $410 million and is second only to the city and county of Denver in assessed valuation and population density.

The district was formed primarily to further the Fryingpan-Arkansas project, but it also has as its aims and objectives future planning and improved water administration. At the present time Pueblo and Colorado Springs each has its own municipal supply systems and both cities and the Twin Lakes Co. import waters by means of diversions from tributaries of the Colorado River to the Arkansas drainage. The only major Federal project on the Arkansas River is John Martin Dam, an Army flood control project located near the town of Las Animas, in the lower end of the river.

The Arkansas River is one of the earliest settled areas in Colorado and was fully developed by 1900. Extensive litigation between Kan-

sas and Colorado resulted in the Kansas-Colorado compact and the program since 1900 has been devoted primarily to better administration. There are no available unappropriated waters in the Arkansas Valley except seldom occurring major floodflows. Any water planning for the Arkansas Valley of necessity pertains either to underground development or additional importations.

All of the present planning has been confined basically to the Fryingpan-Arkansas project. A proposed reclamation project diverting 69,000 acre-feet per annum from the Fryingpan River, a tributary of the Colorado River, to the Arkansas River by means of a transmountain tunnel. There the flow would be supplemented by occasional floodflows from the Arkansas River and the benefits of reregulation making available to the Arkansas Valley a maximum of 186,000 acre-feet of water, most of which comes from reregulation such as the storing of waters which are presently diverted to the fields during the winter months, the moving of shallow plains storage upstream and effecting evaporation savings; also, the impoundment of floodflows. If the Fryingpan-Arkansas project were built and in operation, there would still exist in the Arkansas Valley a shortage of irrigation water of lands presently irrigated of approximately 15 percent of the valley requirements. City water for the metropolitan areas and valley towns would be supplied but not to exceed 15 or 20 years in the future.

In other words if the project were built in 1960, there would still be a 15 percent shortage for the farmer and by 1975 the valley towns would be out of water.

The only other existing project contemplated is a flood-control project near Trinidad, Colo., under the Army Engineers, and if built, this will permit the establishment of a small conservation pool which would assist some of the irrigated acreage below Trinidad on the Purgatoire River. It is not a major project and does not afford a major solution.

The future of the Arkansas Valley will require much planning. It is anticipated that the population of the valley will double in less than the next 40 years and this will in and of itself require approximately another 100,000 acre-feet of water for the increase in population. The solutions probably fall into three major categories: (1) Better administration of existing facilities, (2) control of ground water, and (3) new projects. I will now discuss each of these in that order.

Senator MARTIN. May I ask you a question?

Mr. BOUSTEAD. Yes, sir.

Senator MARTIN. Where you make that estimate based on the population increase, is that computed at the present per capita consumption of water?

Mr. BOUSTEAD. Yes, sir.

Senator MARTIN. Are you not anticipating an increase in per capita consumption of water in keeping with the recent past history?

Mr. BOUSTEAD. No, we are not, sir, because our present per capita consumption in comparison to other communities in this area is a little high.

Senator MARTIN. I see.

Mr. BOUSTEAD. Administration. In connection with administration there is no question but that through research much can be

learned about better means of using the water supplies which presently exist. Research should be conducted both by the Federal and State Governments, and typical problems would be how to prevent the loss of waters in transit or in storage, the study of the problem of detergents, and the resultant effect on irrigation supplies.

Contamination by Federal agencies should also receive close scrutiny. The Rocky Mountain Chemical Arsenal at Denver, although not located in the Arkansas Valley, is nevertheless characteristic of the type of problem which Federal agencies of large scope may present. All of these matters can be studied.

The establishment and utilization of recreation pools consistent with irrigation uses in accordance with State laws likewise deserves attention.

Better administration requires study of pumping and its effect. Little is actually known concerning the ground waters in the area.

Administration can be improved on the surface waters. For instance the John Martin Reservoir is under the jurisdiction of the Army Engineers. Better administration can be had by closer cooperation between the Federal and State agencies in administering that type of project. Admittedly, in the past the administration has not been of the highest order. State legislation of judicial precedent is also required. Better administration likewise contemplates a consolidation of city supplies. At the present time there are overlapping and duplication in city facilities and unquestionably by exchange and consolidation of city systems a more efficient use of water could be obtained. This will require special legislation.

State legislation will obviously be required in connection with any improved methods of administration such as increase in pay for water officials of the State and new statutes making better administration possible. Much better communication facilities are required to permit the closer control of the Arkansas River and the delivery of waters therefrom. Altogether, administration is one phase which deserves close attention and study.

We urge that Federal laws be passed recognizing the paramountcy of State water laws and that the authorizing legislation be so worded as to implement and assist the States in attaining these desired objectives. Conflicts between Federal and State legislative philosophies seem to be largely responsible for existing confusion in administrative problems within the State.

GROUND WATER

Ground water is the second major point which requires study. The rate of use, the rate of recharge, the pollution of ground water, the effect of pumping and the relation of pumps to surface administration are matters which require consideration and the responsibility for the control of which rests solely on the State and not on the Federal Government. The State of Colorado must measure up to its responsibilities in connection with the development of laws applicable to pumps based on adequate engineering investigations on interstate streams, supported by State and Federal appropriations through U.S. Geological Survey matching funds.

At the present time there are unquestionably many pumps which are diverting waters already decreed to surface decrees. On the other

hand, there are no doubt many pumps which are obtaining waters which would never be had by means of surface diversion. This whole problem is one of the greatest importance and is not confined to the Arkansas Valley. It is reasonable to assume that as much as 20 percent of the irrigated acreage of the State is largely dependent on pumps. Many of the towns of the Arkansas Valley have supplemented supplies and are wholly dependent on pumps.

NEW PROJECTS

The new projects required for the future present a number of aspects worthy of comment. Private construction by private individuals for profit will not occur. The amount of money required is so great and the payoff schedule is so long that there is no reason to believe that any individual man or group of citizens will contemplate development of major water supplies. By the same token any one city is such a small segment of the total requirement that city planning by and large will not prove productive. The same is true of valley planning. Future plans for all areas of the State of Colorado must be the responsibility of the Colorado State Water Conservation Board as the official water agency of the State working in close cooperation with the appropriate Federal agencies. It would appear that there is a great need for the Congress to exercise their prerogatives in establishing the rules and regulations to be applied uniformly by all Federal agencies in the evaluation of future projects.

Premium will be on the States to take the leadership in solving their own problems, however, it is true that the Federal Government, particularly in the field of research and in master planning, will in the future as in the past cooperate with the States and make these projects possible. The Federal Government is completely responsible for the consolidation of the requirements of Federal agencies in any one State. A duplicitous overlapping of the water requirements of major Federal installations can be most burdensome on the area. Better planning and better administration between the various units of the Federal Government will do much to avoid duplicity and waste.

It is impossible to foresee what the developments may be. It is certain that the population is going to double in less than 40 years. The only sane sensible solution is to start now to anticipate these requirements to take all possible means to avoid pollution and at the same time to engage in the research that will be required to make it possible for twice the number of people to exist in the areas where shortages exist today.

The Arkansas Valley is beyond all doubt the most critical supply condition of any area in the State of Colorado. There has not been any major development in the valley in the past 60 years other than one small project made possible by the RFC. That is because the valley has been settled so early and its supplies overappropriated for so long that the only solution is the procurement of additional new supplies of water. The Fryingpan-Arkansas project is desperately needed, but it in itself is no final and complete solution.

Thank you.

Senator CARROLL. I thank you very much, Mr. Boustead. It will be very, very helpful to the committee record. Thank you for coming up and testifying.

Any questions?

Mr. Chairman, at this time I would like to offer for the record the statement of the San Luis Valley Water Conservation District given by Mr. Ray Moses. We would like to make this a part of the record at this time.

The CHAIRMAN. Fine.

(The statement follows:)

STATEMENT OF SAN LUIS VALLEY WATER CONSERVANCY DISTRICT, PRESENTED BY RAY MOSES

The San Luis Valley Water Conservancy District, including approximately 250,000 acres of land, in Alamosa, Saguache, and Rio Grande Counties in the San Luis Valley in southern Colorado, with an assessed valuation in excess of $23 million was organized in 1949 to sponsor construction of Wagon Wheel Gap Dam and the Closed Basin Drain, two of the three features of the San Luis Valley project, approved by the Congress and authorized by the Secretary of the Interior on February 1, 1940. The third feature, Platoro Dam and Reservoir, on the Conejos River, was constructed under contract with the Conejos Water Conservancy District, as is now in operation.

Neither Wagon Wheel Gap Dam nor the Closed Basin Drain has been constructed.

The waters of the Rio Grande are apportioned by the terms of the Rio Grande compact, signed March 18, 1938, by representatives of Texas, New Mexico, and Colorado, and approved by a representative of the Federal Government. The compact was subsequently ratified by the legislatures of the respective States and by the Congress of the United States.

Under the compact, delivery schedules for Colorado and New Mexico were established, with allowances made for debits and credits, with a maximum debit allowed of 100,000 acre-feet. Prior to 1952, Colorado operated on the credit side of the ledger, but since that time, a debit has accrued now estimated to exceed 500,000 acre-feet. New Mexico is in a similar status.

By the terms of the compact, any water stored in a reservoir constructed after 1929 is subject to call by creditor States. This provision has effectively prevented the obtaining of consent agreements from owners of water rights in Colorado to permit the storage of decreed water in Wagon Wheel Gap Reservoir, and it is doubtful that such consent agreements can be obtained until a solution to the compact dilemma is reached.

A study of the possibility of water salvage in the Closed Basin area of the San Luis Valley has recently been completed by the Bureau of Reclamation, and a report is now being prepared. It should be available by the end of December 1959.

We are advised that the report will disclose that from 60,000 to 100,000 acre-feet of water can annually be pumped from this area by means of shallow wells without damage to neighboring lands or existing wells.

San Luis Valley Water Conservancy District understands that this committee is not concerned with the merits of individual projects, but the board of directors of the district desires to present this statement because it believes sincerely that national and international water policy is directly affected.

The situation has become acute on the Rio Grande. Because of miscalculation of the draftsmen of the compact, the extended drought, or possibly some other factors not presently known, the compact is not working. The situation erupted into interstate litigation when Texas sought to sue New Mexico in the U.S. Supreme Court. After much expense and worry, the case was dismissed for lack of the United States as an indispensable party. Legislation has been introduced to grant the consent of the United States to be sued.

Any augmentation of the flow of the Rio Grande could be utilized to resolve this unhappy situation and, after the debits had been erased, the pumps could be operated whenever necessary to keep the upper States in compliance.

International obligations through the treaty with the Republic of Mexico would likewise be protected.

Federal construction of this water salvage project would be in the national interest, facilitating the construction of Wagon Wheel Gap Dam wih its flood control benefits, stabilizing the economy of not only the San Luis Valley, but the entire Rio Grande Basin through the assurance of compact deliveries as anticipated by its drafters.

Senator CARROLL. I would like to make another observation here if I may, Mr. Chairman.

If anyone wants to present a statement for the committee record it will be most welcome but it should be sent to my office at room 223, in the New Customs House, and then we will transfer it on to Washington and ask permission of the chairman of this committee to insert it and make it a part of the record. I thought we would do that rather than send it to the committee. Send it to my office at the Customs House.

Mr. Chairman, we have another statement here by Mr. L. R. Patterson, vice president of the Public Service Co. of Colorado, who desires to submit a statement for the record at this time.

The CHAIRMAN. Very good.

(The statement follows:)

STATEMENT BY L. R. PATTERSON, VICE PRESIDENT PUBLIC SERVICE CO. OF COLORADO, DENVER, COLO.

My name is L. R. Patterson. I reside in Denver, Colo. and am vice president of Public Service Co. of Colorado. My address is 900 15th Street, Denver, Colo.

It is a privilege for me to have the opportunity of presenting this statement on behalf of our company to the Senate Select Committee on National Water Resources. This statement is made supplementary and in addition to other statements which we understand will be presented to the committee at this time by the Colorado Water Conservation Board and other agencies within the State of Colorado vitally concerned, as is our company, with the future development of the water resources of this State.

By way of background, let me say briefly at this point that Public Service Co. of Colorado is the largest integrated natural gas and electric utility system supplying natural gas and electric service at retail to ultimate consumers in the State of Colorado. As of June 30, 1959, the company together with its subsidiaries was supplying utility service directly to approximately 324,000 electric customers and to approximately 301,000 natural gas customers throughout various parts of the State of Colorado and in the Cheyenne area in the State of Wyoming. The electric customers served by the company in the State of Colorado directly or indirectly represent approximately 60 percent of the total number of electric customers in the State and the natural gas customers served represent approximately 80 percent of the total number of natural gas customers in the State. The customers of the company, both gas and electric, include many of the principal industries located within the State in addition to the residential and commercial customers in many of the principal metropolitan areas within the State.

As of June 30, 1959, the total capacity of electric generating plants owned by the company in the State of Colorado was 840,750 kilowatts; 96 percent of this capacity was represented by steam electric generating plants fired by natural gas and coal, and 4 percent by hydroelectric or other type generating plants.

Our company has a vital interest in the development of the water resources of this State for domestic, agricultural and industrial use. The long-range growth and prosperity of the State is dependent upon full utilization of the water resources of the State.

Historically, economic feasibility has dictated the industrial development of eastern market areas in the Nation rather than western resource areas. The economy of the West, particularly in the Rocky Mountain area and in the State of Colorado, has been primarily agricultural in nature, although mining has from time to time also played an important part in this economy. With the trend toward western migration occurring in the post-World War II period, however, this region has experienced and is experiencing today a rapid increase in its population and a significant change in the structure of its economy accompanied by a marked increase in the number of new manufacturing and industrial concerns locating in the area. This change has stemmed primarily from decentralization of defense-type industries, the establishment of new industries to serve local and national markets and a step-up in the development of the region's natural resources.

The population and industrial expansion experienced in the State since the end of World War II is expected to continue in the foreseeable future, and as

in the past an adequate supply of water will be a prerequisite for this type of development. Two potential developments that could materially increase the rate of growth and the demand for water for industrial use in the Western part of the State are the oil shale and wood pulp industries. Speaking just of the potential of the oil shale industry, which represents one of the most significant economic potentialities in the State, it has been estimated that if a 1-million-barrels-per-day-capacity plant is ultimately developed in this area, this would result in an additional population in the area of approximately 300,000 persons, required to support such an industry. The water requirements for such a development will be very substantial.

An important index of the future economic development of an area is its estimated future requirements for electric power. Our company has recently completed an analysis and study of the estimated future demands for electric power in the State of Colorado and we believe that this committee may be interested in the results of this study. As of the year 1960, the total electric power requirements of the entire State are estimated to be approximately 1 million kilowatts. By 1980 the electric power requirements of the State are expected to increase to 4,500,000 kilowatts or an increase of 350 percent over the 1960 needs of the State.

The company itself is a large water user. Both fuel and water are needed for large size steam electric generating plants. The company's consumptive use of water in its powerplants is expected to be 8.5 billion gallons of water per year by 1980 or an increase of 550 percent over present needs of the company. Over 85 percent of this usage is for cooling tower makeup.

Considering the State as a whole and the water resources of the State on an average annual basis, it is significant to note that there are adequate supplies of water in the State. Colorado, with its high mountainous areas, which are headwaters of many of the important river basins in the West, is definitely a water supply State. All of the surface water rising in the State, however, flow out of the State by gravity and this has necessitated the State's entering into more interstate water compacts with its neighboring States than any other State in the Nation. One other unique fact about the State of Colorado and its water resources is the fact that today the Colorado River and its tributaries represent the only major undeveloped surface water supply in the State. The pressing challenge in the State today is to fully develop its own water resources which are available but as yet unappropriated or undeveloped.

In an area as small as a State, inequalities in the natural distribution of water leads to real and undeniable local and regional shortages of water. The seasonal and yearly variations in precipitation are also problems which make the use of adequate storage reservoirs necessary. All of these facts are true in Colorado and such facts necessitate the careful planning of manmade distribution facilities and conservation and quality control of water after it has been made available as the means of making water available to all parts of the State.

The planning of large storage reservoirs to increase the dependability of available water supplies should be done very carefully to make certain that the total evaporation loss from the river does not negate the gain from additional storage. This is particularly true here in the West. Generally the point at which evaporation offsets the gain in storage on large reservoirs can be calculated.

Reuse of water wherever possible in industrial applications can increase the dependable supply of water. The company uses this principle in its powerplants. Quality control is also a part of conservation. Most uses of water except for power production change the quality of the water (raise the temperature, alter chemical composition, add to suspended sediment load, or all three). Industrial chemical waste, sewage, and other organic containments, salts leached from soil of irrigated areas and sediment produced in areas where man has disturbed the vegetal cover all depreciate the quality and usability of water. This problem of water quality should not be overlooked in any overall planning of the use of water resources.

Another major problem in the State relates to underground water supply. This and some of the considerations already referred to above will undoubtedly be presented in more detail by other witnesses presenting statements to this committee.

One further aspect of the subject matter before this committee upon which we would like to comment briefly here, however, has to do with the matter of the relationship between the development of the water resources in this State and the production of electric power.

To date the State of Colorado has been the beneficiary of several multipurpose reclamation projects undertaken by the Bureau of Reclamation in our

State, the principal one of which is the Colorado-Big Thompson project in northern Colorado. In addition, in 1956 the Colorado River storage project was authorized, which project is now under construction. Another project is the proposed Fryingpan-Arkansas project, which project to date has not yet been authorized.

In the case of each of these projects, some electric power production has been developed or it is contemplated that such production will be developed. Our company is of the opinion that it is only sound economics in connection with such reclamation projects to develop incidental byproduct hydroelectric power where power generation is economically feasible. In addition, our company has in the past and intends in the future, to cooperate fully with the Bureau of Reclamation in connection with the marketing and distribution of power from such projects.

In connection with the Colorado-Big Thompson project, the transmission system of the Bureau of Reclamation is fully integrated with the transmission system of the company and power from this project is wheeled over the transmission system of the company to preference customers at 22 points of delivery in various parts of the State. In addition, the company purchases electric energy from the Bureau and delivers electric energy to the Bureau.

A similar proposal has been made by the company to the Bureau in connection with the marketing and distribution in Colorado of electric power to be produced by the Colorado River storage project and also in connection with the proposed Fryingpan-Arkansas project.

Where power has been made available or will become available in connection with other water projects in the area, the company has assisted and stands ready to assist in the future in providing a market for such power and energy. Our company financed the original construction of the Palisade powerplant of the Grand Valley project in western Colorado and presently operates such plant under an existing contract with the Bureau of Reclamation. The company has offered to purchase for its system approximately half of the power output of the Collbran project now under construction in western Colorado. To date no other power user has offered to purchase any of this power. The company is presently purchasing hydropower from the Redlands Water & Power Co., a private irrigation development near Grand Junction. Likewise, the company has agreed to purchase all hydroelectric energy developed by the Denver Water Board in connection with its municipal water projects and is presently purchasing electric energy from such board at its recently constructed hydroelectric plant at Williams Fork Dam.

It should be pointed out, however, that the remaining amount of hydroelectric capacity that can be developed in the State under this criteria is small, especially when this is compared to the future power needs of the State mentioned above. The bulk of the future generating capacity additions in the State will be in the form of steam electric generating stations. Tremendous reserves of relatively low-cost fossil fuels exist within the State and can be used for this purpose more economically.

In summary, it is our opinion that sufficient water is available within the State for present needs and for large increases in use. Conservation and farsighted management practices, however, are essential. Nature distributes water very poorly for our purposes, but enough water is available so that by artificial redistribution and conservation, the needs of local areas can be satisfied. Full development of the State's water resources can be achieved only if all agencies, public and private, Federal and local, cooperatively participate in the planning, financing, and construction of the State's water projects.

Senator CARROLL. We are now on schedule. We want to say we are going to do our best to finish by 2:15, not later than 2:30 because Senator Kerr and Senator Martin and the staff have to leave. They have to go out to the airport to fly to Albuquerque and they want to get in there by daylight. I know we all want them to get in there by daylight.

At this time I am going to vary the program a little bit.

Is Mrs. McNickle here, the League of Women Voters?

Mrs. MCNICKLE. Yes, sir.

Senator CARROLL. Are you ready to come forward, please?

Mrs. MCNICKLE. Yes.

Senator CARROLL. The reason I vary the agenda is that both the chairman of the committee and Senator Martin are very anxious to hear the opinion of the League of Women Voters and we do not want you shut off in the possibility of hurried closing minutes of this committee.

Mrs. MCNICKLE. Thank you.

Senator CARROLL. The League of Women Voters nationally has shown a great interest in water development. We know that the League of Women Voters in the State of Colorado has a great interest in this matter, too. So would you please proceed, Mrs. McNickle?

STATEMENT OF MRS. D'ARCY McNICKLE, STATE WATER RESOURCES CHAIRMAN, LEAGUE OF WOMEN VOTERS OF COLORADO

Mrs. MCNICKLE. Mr. Chairman and Senator Martin: My name is Mrs. D'Arcy McNickle. I am the State water resources chairman for the League of Women Voters of Colorado.

Knowing that you are pressed for time now I do not intend to read this entire statement, though it is rather short. What I would like to do is to indicate to you the areas which have not been covered or covered lightly by other speakers.

The CHAIRMAN. This statement in its entirety may be made a part of the record.

(The statement referred to follows:)

STATEMENT OF THE LEAGUE OF WOMEN VOTERS OF COLORADO PRESENTED BY MRS D'ARCY MCNICKLE

THE CITIZEN'S ROLE IN WATER RESOURCE DEVELOPMENT

The League of Women Voters of Colorado, which I serve as State water resources chairman, is pleased to have the privilege of appearing at this field hearing of your committee. Having listened to our State officials, members of our research institutions, and representatives of various areas of Colorado, you may be interested in hearing from a group of citizens who share with the previous speakers concern for the State's water resources.

Our organization is dedicated to the proposition that a democracy cannot thrive without the active participation of informed citizens. And in no area of government is an informed citizenry more essential than in water resources.

As members of the League of Women Voters of the United States, we have been studying some problems of the Nation's water resources over the past 4 years. In addition, Colorado league members have been working for nearly 3 years on the water problems of our own State. We undertook this program because it seemed to us that, judging by our own knowledge, most citizens of Colorado have very little understanding about the water resources of their State, how they are used, and how central they are to the whole future development of Colorado. We began by preparing a kind of primer on water in Colorado, which is before you. I should like to submit this pamphlet for the record.

On the basis of our work during the past several years, I shall speak briefly today on what the Colorado League of Women Voters feels might be some useful considerations in national water policy. Then I shall indicate some aspects of our State and regional water problems which have significance for national policy. Basic to these remarks is the conviction that an adequate water policy can be made and activated only with the participation and support of citizens throughout the Nation.

NATIONAL POLICY ON WATER RESOURCES

Positions taken by the League of Women Voters on national issues come from the grass roots. Each local league, after considerable study and discussion, decides what it believes is the best solution for a particular problem of government. Then, on the basis of consensus reported from leagues in a thousand com-

munities in 50 States and the District of Columbia, the national position is determined. The 15 Colorado leagues have just reached consensus on national water policy. While our position will doubtless differ somewhat from that of other States, we believe it may be of some interest to your committee.

In the first place, we welcome the creation of the Select Committee on National Water Resources. Its broad representation of all the standing committees of the Senate which deal with water development can do much to secure a unified approach to water resources, as well as to arrive at estimates of future water needs of the United States and ways of meeting these needs. Field hearings in all sections of the country seem a highly appropriate beginning to determine the connection between water resource development and the national interest.

Resources and Conservation Act

We are also impressed with the potentialities of S. 2549, the Resources and Conservation Act of 1960, of which several of your number are cosponsors. From time to time since World War II, valuable studies have been made of national needs and policy in the resource field, but little action has resulted. However, if a permanent council were created to advise the President on conservation and development of natural resources, the Nation would have the enormous advantage of a focal point where information could be collected and analyzed on a continuing basis, and recommendations could be made for coordinating the work of the many Federal agencies dealing with resources. An annual resources report by the President would give the Congress a firm basis of fact on which to base decisions. A Joint Committee on Resources and Conservation could serve to offset the splintered jurisdiction in water and other resources that now exists in the legislative branch. Most valuable of all, both the executive and legislative branches and the country as a whole could see the total needs for resources and the interdependence of each resource upon all the others.

In the economic field, the combination of a Council of Economic Advisers, an annual economic report by the President, and a joint committee on that report has been one of the most useful governmental innovations in recent decades. We believe that a similar arrangement could be equally successful in the field of natural resources. From it might in time result a national water policy which is more than an aggregation of projects.

Development of national water policy

What might be some concomitants of a national water policy? We believe that one necessary element is the assumption that States, local governments, and private individuals should carry a larger share of the cost of water projects. Such governmental units as the Northern Colorado Water Conservancy District, which is helping to repay Federal investments in the Colorado-Big Thompson project, might well be used widely as a means by which citizens who benefit indirectly but vitally from Federal projects could share the cost. We also believe that repayment could be made by beneficiaries of some kinds of projects where Federal expenditures are now nonreimbursable, including flood control and navigation where beneficiaries can be clearly identified.

It might also be suggested that the Nation could safeguard its investments in water by conditioning them partly on conservative use of water or land. Would it not be feasible to require that cities and industries which secure water from federally financed projects should return it to the stream in usable form? Could authorization of Federal flood control expenditures be made conditional upon passage and enforcement of State flood plain zoning? Similar conditions might be attached to conservative use of water for irrigation, not only of crops but also of city lawns.

Water that is, or can be made, available will surely have to be stretched to the utmost to cover the needs of our rapidly growing Nation. This is particularly true in regions like ours, where burgeoning population is already pressing hard upon limited natural supplies of water. The time is past when any individual or group can expect to buy water like any other commodity and use it as they see fit. The Nation has an interest in the water itself as well as the public funds invested to develop it.

It need hardly be said, however, that local citizens will be unwilling either to shoulder a larger share of the cost of developing water or to use it conservatively unless they understand why they should be willing. To help bring about such understanding is clearly a responsibility of government at every level, if both our economic and our water resources are to meet the demands upon them.

REGIONAL ASPECTS OF NATIONAL WATER POLICY

Pollution control

Several aspects of water use in Colorado and the other States of the Mountain West point up water problems that are found everywhere in the Nation, though often to lesser degrees. One of these is the problem of waste of water through pollution by municipal sewage. This may seem paradoxical in a sparsely populated region, but reasons are not far to seek. In a region where natural stream flow varies greatly and variability is increased by many diversions and return flows, sufficient water to dilute sewage effluent may be available one day and not the next. In a low-flow period, this creates wide fluctuations in both quantity and quality of water available downstream.

Moreover, population in this region tends to concentrate in relatively small areas of our wide open spaces. For example, nearly half the population of Colorado is located in Denver and the four surrounding counties. Thus, unless closely neighboring communities have deep-well supplies, they must perforce get their water from surface flow, often the flow of one stream. Where this is the case, a community may take its water from a stream not far below where its neighbor discharges sewage.

It should also be remembered that, in a region where water is at a premium, rapidly growing cities and towns often strain their financial resources to secure an adequate water supply, and are unable or unwilling to build a sewage disposal plant. This is not an equitable situation, from the point of view of water users downstream, but it is understandable.

This difficulty has been partly overcome since 1956 because Federal grants have served as incentives to communities for building proper disposal plants. In 1959 in Colorado, the value of plants under construction was more than double what it had been just before the Federal grant program began. But each year there is a backlog of applications for aid which cannot be covered by Federal funds available to Colorado.

Since both the effectiveness of the grant program and the insufficiency of present Federal appropriations to meet need have been demonstrated all over the country, it is to be hoped that Federal funds can be made available in increased amounts, as provided by H.R. 3610, passed by House and Senate this session. The bill's provision for adjacent communities to pool their entitlements in order to build joint disposal plants would be of great assistance to mushrooming metropolitan areas which now characterize the American scene. We hope that action on H.R. 3610 can be completed speedily.

Water for recreation

Another great need of the Mountain and Plains States is water for recreation. Recreation is big business in Colorado, where tourists brought about $1 million a day to the State during our centennial year just ended. But is is more than business to Colorado citizens. The use of reservoirs built by the Corps of Engineers and the Reclamation Bureau has risen phenomenally, and it is now said that every puddle in the Plains has one boat and six fishermen. Boat salesrooms are commonplace on the main streets of Plains towns that get 10 or 15 inches of rain a year.

Such demand for water-based recreation is bound to grow with our cities, with more leisure, and with the greater mobility of our population. Perhaps it is at this point that citizens will enter most enthusiastically into planning for water resource development. Colorado citizens have learned that it would pay to be in early on the planning for recreation. They have learned it the hard way, from the spectacle of thousands of fish dying as John Martin Reservoir on the Arkansas was drained for late-season irrigation.

Public understanding and participation in water resource development

It is inevitable that citizens of the United States are going to be increasingly concerned with the development of the Nation's water resources. They have a direct interest in the financing of development projects because they furnish the financing. In a time of increasing demand for water, they have also a direct interest in how the water is used. But such concern, to be really useful to legislators and administrators who make the final decisions, must be based on sound public understanding.

In this part of the country we are often impressed with how little is known about our water problems by our fellow citizens in the humid areas. They ask, for example, why we do not set aside blocks of water for development of industry in the future, not realizing that this would undermine the whole system

of prior appropriation set up to insure ready and equitable access to water in a dry area.

Westerners realize, of course, that the understanding of regional problems is a two-way street. We need to understand more fully the water problems of the East and South. For this reason, the League of Women Voters of Colorado believes that public understanding of water problems should be a specific objective of national water policy. The means are at hand in schools, the mass communications media, and other recognized methods of informing the public. What is needed is some planning to use these methods for an objective that is of significance to the Nation as a whole.

We also believe that, within regions, the citizens are entitled to know the possible alternatives for the use of water and public funds before any project plan becomes final. Would it be better, for example, to develop a project to provide for full use of water for recreation along with other uses? Would diversion of water from one area of a region to another be more productive of economic growth and general welfare?

It is not suggested that all the citizens of an area should—or could—participate in all stages of planning for water resource developments. What is suggested is that the technical planning group should provide adequate information to the public in the early stages of planning, should invite comment and suggestions from interested citizens and groups before a final plan is formalized, and should give serious consideration, after public discussion, to alternative uses of water resources.

While is is true that public hearings are routinely required now, too often they are inadequately publicized, and too often the public is presented with a formal plan—take it or leave it. Machinery for securing public participation at the appropriate stages is at hand in the various interagency committees and interstate commissions. Effort needs to be made to develop this machinery for much wider contact with the public.

In closing, I should like to suggest that Senators stop on their way out of this building to look at the murals in the rotunda. They are designed to illustrate a poem which begins:

> "This is a land where life is written in water.
> The West is where the water was and is."

All of us know the truth of this statement for the West. It is significant now for all of the United States. I commend it to the attention of the Select Committee on National Water Resources.

Mrs. McNICKLE. Thank you.

The CHAIRMAN. And as far as I am concerned I would be happy for you to take such of the time allotted to you as you desire to.

Mrs. McNICKLE. Thank you, Senator.

As Senator Carroll has indicated, the League of Women Voters in Colorado has been working not only on the problems of national water resources but on the water problems of our own State for the past 3 years.

As a beginning in this work we undertook to educate ourselves, because we felt that judging by our own lack of knowledge other citizens probably were in need of this sort of thing. So we compiled a kind of primer of water resources in Colorado which is before you, and I should like to submit that for the record.

Senator CARROLL. Mr. Chairman, this is a very, very fine document and it shows a great amount of work. It is probably too voluminous to put in the record. I wonder if this could not be placed in the committee files.

The CHAIRMAN. I would be very happy to have an adequate number of copies for the committee files.

Mrs. McNICKLE. All right.

The CHAIRMAN. Yes.

I would say this to you, that the committee will digest this document and the information it finds in here which has been not otherwise put into the record we will make a part of the record.

Mrs. MCNICKLE. Thank you very much.

The CHAIRMAN. Yes.

Mrs. MCNICKLE. You will find, incidentally, some of the answers to questions that were raised previously that we did not have things at hand with our fingers on, such as State line flows which are on page 4 of this document.

The CHAIRMAN. Yes.

Mrs. MCNICKLE. You can also see from the map at the first of the publication the areas which are drained by the various major tributaries. I think that is a help to most of us.

On the basis of our work during the past several years, I want to speak briefly today on what the Colorado League of Women Voters feels might be some useful considerations in national water policy. Then I shall indicate some aspects of our State and regional water problems which have some significance for national water policy, we believe.

But basic to these remarks is the conviction that an adequate water policy can be made and activated only with the participation and support of citizens throughout the Nation.

After a considerable period of study we would like to make these comments on national water policy.

We, too, welcome you to this State. But we welcome the creation of the Select Committee on National Water Resources partly because of its broad representation from all the standing committees of the Senate which deal with water development. We think that this can do much to secure unified approach to water resources, as well as the arriving at estimates of future water needs.

As to the other responsibilities which were given to your committee, we are also impressed with the potentialities of S. 2549, the Resources and Conservation Act of 1960, of which several of your members are cosponsors.

From time to time since World War II we have had valuable studies of national needs and policy in the resources field but little action has resulted. However, if a permanent council were created to advise the President on conservation and development of national resources, the Nation would have the enormous advantage of a focal point where information could be collected and analyzed on a continuing basis, and recommendations could be made for coordinating the work of the many Federal agencies dealing with resources. An annual resources report by the President would give the Congress a firm basis of fact on which to base decisions. A joint committee on resources and conservation could serve to offset the splintered jurisdiction in water and other resources that now perforce exists in the legislative branch. Most valuable of all, both the executive and legislative and the people as a whole could see the total needs for resources and the interdependence of each resource upon all the others.

In the economic field the combination of a Council of Economic Advisers, an annual economic report by the President, and a joint committee on that report has been one of the most useful governmental innovations in recent decades. We believe that a similar arrangement could be equally successful in the field of natural resources. From it might in time result a national water policy which is more than an aggregation of projects.

What might be some concomitants of a national water policy? We believe that one necessary element is the assumption that States, local

governments, and private individuals should carry a larger share of the cost of water projects.

I realize I am not in full agreement with many previous speakers. But such governmental units as the Northern Colorado Water Conservancy District, which is helping to repay Federal investments in the Colorado-Big Thompson project, might well be used widely as a means by which citizens who benefit indirectly but vitally from Federal projects could share the cost. We also believe that repayment could be made by beneficiaries of some kinds of projects where Federal expenditures are now nonreimbursable, including flood control and navigation where beneficiaries can be clearly identified.

The CHAIRMAN. May I ask you a question there?

Mrs. MCNICKLE. Yes.

The CHAIRMAN. Would you carry that policy to the highways?

Mrs. MCNICKLE. I am sorry, I do not follow you, Senator.

The CHAIRMAN. I said would you extend the application of that policy to our highways?

Mrs. MCNICKLE. This is not a question on which I am very well informed.

The CHAIRMAN. The reason I ask you that question——

Mrs. MCNICKLE. Yes.

The CHAIRMAN. Is because it is a very live question.

Mrs. MCNICKLE. Yes.

The CHAIRMAN. For instance, we are engaged in the building of a 40,000-mile Interstate Highway System which the Federal Government is paying on the basis of 90 percent to 10 percent for the States. And the 90 percent is nonreimbursable.

Now, would you feel that if you were going to make the reimbursable feature applicable to navigation that you would feel impelled to apply it also to reimbursing the Federal Government for the expenditures on the highways?

Mrs. MCNICKLE. I should say this is my personal opinion because the league has not studied this, you understand.

The CHAIRMAN. I understand.

Mrs. MCNICKLE. I would say that the highway program is based on an earmarked tax source, is it not? And general funds of the Treasury are available for water resources development. All of us pay those taxes. Most of us pay the gas taxes, too, but that is set up in a very different way as to financing originally, is it not?

The CHAIRMAN. At this time a part of the taxes people pay in connection with their use of the highways goes into the highway users' fund. That has not long been the situation, nor is it the situation now that all of the tax that people use in connection with their highway use goes into the fund.

Mrs. MCNICKLE. I see.

With flood control, particularly, we are interested in a bill, and I assume it is the administration bill, Senator Bush's bill.

The CHAIRMAN. Yes, 2080, I think.

Mrs. MCNICKLE. Yes, I believe it is.

The CHAIRMAN. Yes.

Mrs. MCNICKLE. Which proposes non-Federal contributions.

It might also be suggested that the Nation could safeguard its investments in water by conditioning them partly on conservative use of water or land. Would it not be feasible to require that cities and

industries which secure water from federally financed projects should return it to the stream in usable form? Could authorization of Federal flood control expenditures be made conditional upon passage and enforcement of State flood plain zoning? Similar conditions might be attached to conservative use of water for irrigation, not only of crops but also of city lawns.

Water that is, or can be made available will surely have to be stretched to the utmost to cover the needs of our rapidly growing Nation. This is particularly true in regions like ours, where burgeoning population is already pressing hard upon limited natural supplies of water. The time is past when any individual or group can expect to buy water like any other commodity and use it as they see fit. The Nation has an interest in the water itself as well as the public funds invested to develop it.

I turn now to specific aspects of our regional water problems and State water problems which have some bearing on National water policy.

One of these is the control of pollution. Both Mr. Sparks and Mr. Saunders have spoken about this.

We feel, as a league, that the final action on the Blatnik bill would in its present form, both the House and Senate versions, would make the combination of pooling of entitlements possible and is a good thing.

The CHAIRMAN. I want to put into the record that the personnel of the Public Works Committee here, Mr. Johnny Mutz, has told me since the previous testimony that under the provisions of the bill as passed both by the House and the Senate there is no limit on the number of communities that could participate in the single project and that each one participating would be eligible to receive the $400,000 contribution from the Federal Government.

Mrs. MCNICKLE. That will materially help in situations like the Denver metropolitan area.

Senator CARROLL. Thank you very, very much for a splendid statement.

Any questions?

The CHAIRMAN. No. I thank the lady for the statement.

Senator CARROLL. The next witness—we are moving along well here. I hope we can stay on our timetable.

Mr. Robert Barkley. Mr. Barkley is the secretary-manager of the Northern Colorado Water Conservancy District. This is a district served by our largest Colorado reclamation project known as the Colorado-Big Thompson project.

Mr. Barkley.

STATEMENT OF ROBERT BARKLEY, SECRETARY-MANAGER, NORTHERN COLORADO WATER CONSERVANCY DISTRICT

Mr. BARKLEY. Thank you, Senator. Mr. Chairman and members of the Senate select committee, Senator Carroll has indicated my name is J. R. Barkley. I am secretary-manager of the Northern Colorado Water Conservancy District, a quasi-municipal corporation which is the contracting agency with the United States for the construction of the irrigation facilities of the Colorado-Big Thompson project. Over

the years this project has had sufficient publicity that it seems unnecessary here to cover certain of the details regarding its construction and operation. However, there are certain facts relating to the area served by Colorado-Big Thompson which are worthy of mention. One hundred years ago last month the first decreed water right in eastern Colorado was established just outside of the foothills on one of the South Platte River's principal tributaries.

This was the beginning of an irrigated agriculture which was developed wholly by private initiative and which, by 1900, extended to more than three quarters of a million acres and, more importantly, to the limit of the water supplies available in the South Platte River Basin. While the productive capacity of the soils and the ability of the farmers within this area rank high among the irrigated areas of the West; the farm economy was subjected to the highly variable and limited water supplies common to the semiarid West.

The combination of drought and economic depression in the early 1930's gave rise to the promotion of a transmountain diversion project which would import waters from the Colorado River Basin to the South Platte. Thus the Colorado-Big Thompson project was designed to conserve and import surplus waters from the Colorado River solely as a supplemental supply to the farmland, municipalities, and industries of the South Platte. The annual transmountain diversion of approximately 300,000 acre-feet increases the basic supply to the service area in the South Platte Valley by about 25 percent. As you know, I am sure, construction of Colorado-Big Thompson was carried out by the U.S. Bureau of Reclamation under contract with Northern Colorado Water Conservancy District. After 18 years of construction which commenced in 1938, the project was completed and our district, serving some 750,000 acres of irrigated land, is now the largest operating entity of its kind in this country.

With that brief background, I should like to direct your attention to the conservancy district organization itself and its appropriateness for the financing and operation of a public works project. The present national administration has made frequent reference to the "partnership" approach in the development of federally constructed projects. The Congress itself, in recent years, has indicated an increasing interest in local participation in federally sponsored projects. The conservancy district type of organization, as authorized here in Colorado, offers an excellent form of entity to accomplish this local participation purpose. Briefly, a conservancy district may be organized in Colorado by proper petition to the appropriate district court when such petition is signed by the required number and class of property owners. The board of directors, either appointed by the court or elected, has power to acquire and hold property, appropriate water, enter into contracts, levy taxes and assessments, issue bonds, construct works, allot water, and generally administer the business of the district. The board has the power to contract with the United States for construction of work when the same has been authorized by an election of property owners. The Colorado act further provides procedures for allotting water to individuals, municipalities, corporations, and irrigation districts and for collecting special assessments for the use of such water. Of more importance from the standpoint of the "part-

nership" approach or from the standpoint of local participation, a conservancy district board may levy taxes on all real and personal property as a reflection of the indirect benefits to be derived from project construction and operation.

Obviously, this is a known tax burden which is imposed by the local citizens themselves by the very act of petitioning for district formation. For districts of our size, Colorado law limits this ad valorem levy to one mill. Even with this limited mill levy, 45 percent of the revenues of Northern Colorado Water Conservancy District arises from the one mill general levy against all real and personal properties within the district.

In the West, at least, this type of entity with the broad powers delegated to its board of directors should be adequate for the local participation necessary to the construction and partial financing of future Federal reclamation projects. It provides the necessary mechanisms for the repayment of capital costs by both the direct beneficiaries and those who are indirectly benefited from the wealth produced by a stabilized or increased agricultural economy. Here, I would like to inject the suggestion that this local participation by both direct and indirect beneficiaries need not be limited solely to the reclamation projects of the West. Many of the water resource development programs of the Federal Government, including flood control, navigation, salinity control, recreation, and fish and wildlife benefits, are not always wholly in the national interest. Therefore it seems appropriate that the direct local beneficiaries should, in many cases, participate in the financing of these projects. What is really being suggested here is greater uniformity by the Federal Government in the authorization, cost allocation, financing, and repayment of all water resource development programs. One element in particular is worth emphasizing as an example. The costs of many projects developed under reclamation law are being repaid by contracting entities representing the users of water and hydroelectric power. However, vast recreational facilities have been automatically created with the construction of the lakes, canals, and reservoirs which are created as a part of these project systems.

There is some thinking in the West that the cost of these recreational aspects should be assigned a part of the total project cost and that such allocated share should be nonreimbursable. However, in all fairness, it would seem more appropriate that any project cost allocated to recreational benefit should be repaid, to the greatest degree possible, by those who utilize and benefit from the recreational facilities. This repayable share could and should be determined prior to project authorization and appropriate entities formed to contract for the operation, maintenance, and repayment responsibilities.

While I realize that, because of pending legislation on the subject, your committee does not wish to deal directly with the Federal-State relationships in regard to water rights, it does appear appropriate to point out that, if the Federal Government wishes local participation in the development of water resources, the Congress must recognize and protect the investments of private citizens. Otherwise, those citizens cannot be expected to accept the burden of developing even those projects which require no Federal help if the United States

may, through the reservation theory, come in at any future time and completely obliterate the asset value of rights acquired in the process of private development. On this very point, there are numerous additional developments for purposes of conservation, reregulation and further stabilization of water supply which could be accomplished within our district or within the South Platte Valley. Many of these are of a character that might be done by local corporations, ditch companies, the conservancy district, or a combination thereof.

However, since the water supplies of this State arise almost wholly on federally owned or reserved lands, it is doubtful that these needed developments will be accomplished until the Congress gives assurance that the water right values involved will not be taken over by the United States under the reservation or withdrawal theory.

While our district serves an area which has practiced irrigation for 100 years, there remain many things which need to be known and which need to be done to accomplish greater beneficial use of our existing and imported water supplies. This is particularly true as our population rapidly increases and competition becomes greater and greater for our already limited water supplies.

It is important that we save water by improved and more economical methods of canal lining; by phreatophyte control; by control of salinity and alkali problems; by maintenance of soil fertility, or by solution of many other problems which are common throughout the United States. On these matters we would respectfully suggest that the Federal Government might well participate to a much greater degree in the research fields necessary to derive the appropriate answers to these many and varied problems. Centralized research by the Federal Government precludes the necessity for duplication by the States and can provide, appropriately we think, the research services which can neither be individually afforded nor effectively organized by its private citizens. Further, the Federal Government itself has billions of dollars invested in water resource projects of all types and, in the general public interest, should be looking toward more beneficial use of the water supplies so developed through appropriate research programs.

With the wide variety of water resource problems throughout these United States and with the many Federal agencies involved in development programs, your committee has a tremendous task before it. We appreciate the opportunity of appearing before you and we can only hope that our few suggestions may be helpful.

Thank you very much.

Senator CARROLL. Thank you very much, Mr. Barkley.

Mr. BARKLEY. Surely.

Senator CARROLL. Mr. Chairman, I see a former Governor of Colorado, who is also a former U.S. Senator from Colorado, in the audience, and I would like to see if Governor-Senator Ed Johnson would give us a few words.

We are trying to meet a deadline here but I think he knows more about the Colorado River and the water problems of Colorado than anybody in Colorado today. And we would be happy to hear from him for any sort of statement he would like to offer. He is also Colorado's member on the Upper Colorado Commission. You are a member of that commission, are you not?

STATEMENT OF HON. ED C. JOHNSON, FORMER U.S. SENATOR FROM THE STATE OF COLORADO

Mr. JOHNSON. I am the Colorado member of the Upper Colorado Commission.

Thank you, Senator, for the courtesy of extending me an opportunity to say a word. I want to join our very able Senators from Colorado, Gordon Allott and John Carroll, in extending a word of appreciation to our visiting Senators from Iowa and Oklahoma, coming here and holding this hearing.

It pleases us very much. Water is a tremendously important resource in Colorado and we know it. We have gotten to the bottom of the barrel in most of our streams.

And we know what this resource means. The soil and the air and the water are our basic resources. We have many other resources that add to the good living but water we cannot do without.

So any program that conserves water and puts more of it to beneficial use is a great godsend.

I appreciate this opportunity to say these few words and thank these men for coming here and helping us. We know of your interest. Ours is a selfish interest born from experience. We know what it means. We didn't know that our good neighbor in Iowa, Senator Martin, and we did know that our good neighbor from Oklahoma appreciates water because they have a little drought down his way once in a while and Senator Kerr knows about that.

But after hearing Senator Kerr's brilliant address last night I know that he has a true evaluation on this great resource and so we are just pleased as we can be that Congress, that you Senators, are interested in conserving water and putting it to the best use possible, because in times ahead it is not only going to be our most precious resource but it is going to be our most scarce.

I thank you, John for letting me say these few words.

Senator CARROLL. Thank you. It was the chairman and Senator Martin, I know, that wanted to hear from you with your great experience.

Any cross-examination of the former Governor and Senator?

The CHAIRMAN. I learned a long time ago when Ed Johnson was around to listen and hold and contain myself in the status of being the listener. I am always glad to be the listener when he talks.

Mr. JOHNSON. Thank you.

Senator CARROLL. Senator Martin?

Senator MARTIN. I would like to add a word that my experience in Congress, starting 21 years ago, I learned to look to Ed Johnson many times for counsel and advice. We worked together on some matters quite extensively, you remember, during my service in the House of Representatives.

Mr. JOHNSON. Yes, sir.

Senator MARTIN. We are delighted to have you here with us today.

Mr. JOHNSON. Thank you.

Senator MARTIN. It is a great privilege indeed to have you with us.

Mr. JOHNSON. I am sure glad to see you here, Senator Martin.

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Senator CARROLL. Thank you very much, Governor Johnson.

Now, the next witness will sort of sum up as I understand. This is Mark Shivers, the chairman of the Colorado Water Congress. Previously I had introduced to the committee John Barnard, who is assistant attorney general and a former chairman of the Colorado Water Congress. Now the present chairman, Mark Shivers, will come forward and give us a quick summary. We are right on the deadline. We are coming along here and I have two further witnesses, one I want to introduce and the other to make a few observations. We are running close to the deadline but I don't want in any way to shut off Mr. Shivers. I do want to thank him for the excellent work he has done in helping present the witnesses and to help present this program in such a cogent fashion.

STATEMENT OF M. O. SHIVERS, JR., CHAIRMAN, COLORADO WATER CONGRESS

Mr. SHIVERS. Thank you, Senator Carroll.

Honorable chairman and members of the committee, I am not exactly in the position of summing up the entire testimony.

It is an honor for me to be permitted to appear before you this afternoon in behalf of the Colorado Water Congress. As chairman of that organization, I extend a cordial welcome to the State of Colorado, and express sincere appreciation for your courtesy in holding a hearing in our State.

Our executive director, Mr. John B. Barnard, Jr., appeared before you at Laramie, Wyo., and presented comments concerning many specific problems to which the Water Congress has given serious consideration since its inception.

If you permit, Senator Kerr, your comments this morning were most pleasing to me. I realize that you perhaps concur or certainly are sympathetic to some of the views I am about to express.

It is my intention today to deal essentially, and in generality, with one particular problem, namely, that of the need for greater coordination among agencies of the Federal Government charged with the duty of attempting to resolve various water conservation problems, and the necessity for legislation to bring about the uniform application of basic principles for water resource development. Included in this problem is, of course, the necessity for uniform basic principles and coordination of activities on a State and local level, as well as on the Federal level. It is my understanding that the committee is primarily concerned with those matters in respect to which the Federal Government has the only, or the prime, responsibility.

Briefly, however, I may say that at the time of the organization of the Colorado Water Congress, it had become apparent that in the State of Colorado something had to be done to effect a greater coordination of agencies dealing with water resource development within the State. At about that time, also, Governor McNichols had a committee studying the need and possible operation of a new department of natural resources for the State. This department has since been implemented, and those of us who are interested in the proper development of water for varied purposes, and in the development of other natural resources, believe that this centralization in one department may well serve toward bringing about coordination within the State.

In the beginning of water conservation development projects by the Federal Government, the agencies with whom the work appeared to be most closely related were assigned the responsibility of initiating and carrying out such work. At the outset, projects were pretty much single purpose in nature, directed to meet a specific requirement at the specific time a given project was initiated. For example, the reclamation program was activated for the specific purpose of providing irrigation for theretofore arid lands.

The necessity of repayment brought about power developments in connection with these irrigation projects. At the present stage of development in the Western States, it has become increasingly apparent that no project can longer be viewed solely from the reclamation standpoint. Almost without exception, other benefits accrue from irrigation projects by virtue of the fact that the water supply automatically includes a certain amount of flood control and the finished project provides an excellent area for recreational use of impounded waters and the possibility of water supply for municipal and industrial uses within the project area. These are only a few of such additional benefits among many others.

At present, however, regardless of the fact that virtually every reclamation project involves some flood control, and conversely flood control projects in the west frequently involve conservation storage, two separate and distinct agencies continue to construct and maintain projects which, though similar in character, are governed by different rules as to feasibility, construction, maintenance and operation. In addition, in the past few years we have seen an entry into the water conservation field of an additional agency. I refer to the program now in existence and being carried out by the Agriculture Department.

Here in Colorado, we have several excellent examples of the need for closer coordination among these various Federal agencies, and also excellent examples of the fine results which accrue when through coordination multipurpose projects are constructed. Some time ago a flood-control project was constructed southeast of the city of Denver on Cherry Creek and for years stood, except for a little seepage, as a dam without a purpose, except for the ever imminent danger of serious flood which had occurred in the past. It was not until the State of Colorado, acting through its governor and congressional delegates, brought forward the possible recreational value of this flood control project that development was undertaken by the State and the Corps of Engineers, jointly, to bring about such development. It now appears that this flood-control project may become one of the outstanding recreational areas in the State.

On the other hand, in eastern Colorado on the Republican River, through the joint efforts of the Bureau of Reclamation, the Corps of Engineers, and the Fish and Wildlife Service, a multipurpose project for flood control, water conservation, and recreational use was constructed. Its value to the State as such a multipurpose project is clearly indicated by the widespread use of the facilities for all of these purposes. There remains one problem which is rather complicated, and that is the problem of coordinating the methods of operation of the water in the reservoir by the Bureau of Reclamation and the Corps of Engineers under divergent policies.

Senator CARROLL. May I interrupt you to say at this time, Mr. Chairman, many years ago the Colorado-Big Thompson was labeled a gigantic boondoggle. You heard the brilliant testimony of its achievement today. I am very happy to have Mr. Shivers mention the Cherry Creek project. This was another alleged boondoggle and we were lampooned by the press asking why this was ever constructed. Now, as the witness indicated, it is of great benefit to the area.

Mr. SHIVERS. It is, sir.

In the light of these examples, it is suggested for the consideration of this committee that a program of centralization is indicated, similar to that adopted in Colorado through the department of natural resources, to effect coordination among the various Federal agencies. Granted, under existing law, coordination does exist, and the agencies appear at the present time to be working well together; nevertheless, the impact of Federal activity in natural resource development is steadily increasing and the problem of cooperation among the agencies, regardless of desire for coordination, are becoming more complicated as time passes. Consequently, areas do appear where there is inadequate coordination of effort, primarily due to conflicting departmental policies, criteria, and standards. When lack of coordination does occur, its impact on local areas is becoming increasingly important.

It may be wise to consider the possibility of placing all water resource development agencies under one administrative department devoted entirely to that purpose, or at least placement of such agencies within one department where the same rules, criteria, regulations, and policies can govern all phases of water development. Of course, there would be serious questions as to whether such a new agency should be of Cabinet or subcabinet level in the executive department; or whether it should be organized as a separate administrative branch. The details of this would, of course, have to be carefully studied to determine the most effective means of bringing about a unified and coordinated administration of water programs.

Referring again to the fact that some water projects originally developed for specific needs, in a specific way, frequently develop into multiple-purpose programs, it should be noted that the various types of Federal activities began at widely different times. Consequently, policies were adopted by each agency which were tailored to fit the particular problem to which a specific activity was directed, influenced by the political climate that existed at the time of the initiation of the program. Because these have varied so widely, we have now come to the point where many separate agencies are involved in doing essentially the same thing, but under policies which have continued in existence for various reasons and various periods of time, resulting in those policies being widely different among the different agencies. This is true particularly in connection with feasibility standards and criteria, in spite of efforts made to achieve a greater uniformity in this respect through coordination between the agencies properly responsible for different aspects of water use developments.

It is also clearly a fact that in connection with the problem of repayment of funds expended for various project developments, wide variances in feasibility criteria are found. There may be good reason for each policy taken alone, but when the different rationale is applied by the various agencies, the results can become incongruous. I am

not qualified to go into detailed analysis of these matters, nor would it be useful for me to do so. However, one is certainly hard pressed to find a valid difference between protecting lands from an excess of water, and protecting lands and agricultural productivity from a shortage of water. Yet, in the first activity, benefits conferred are not reimbursable; in the second, they are. Other examples could be cited.

In relationship to water conservation programs in the Western States with the years of experience and history which we now have behind us, it would seem in order that a review of standards and criteria for determining project benefits should be had on a congressional level.

In many instances, projects have been rejected as being infeasible because of criteria which do not realistically appraise the many different benefits which could be realized from the project if constructed. Sometimes these basic standards remain unchanged even when technology has actually improved water usage and necessitated a new standard. One project in Colorado experienced serious difficulty over the question of its feasibility, because many of the project lands had a slope in excess of that which is required for class I lands. As a result, they were classified as class IV. This, in spite of the advent of sprinkler systems of irrigation by which lands with a similar, or greater, slope were actually being successfully irrigated in the same vicinity.

Another example of inadequate consideration of water benefits frequently occurs, as I have pointed out before, in underevaluated benefits to be realized from recreation and multiple use. It may very well be that the basic criteria applied by the various agencies are failing to keep pace with the tremendously important increase in recreation facilities, with technical development of uses, industrial uses and improved water conservation practices.

In making this statement, I am not unmindful of the many highly important phases of research being carried on by the various agencies, separately, in many of these fields. I am referring rather to the need for modernization of criteria by all agencies.

If the basic criteria for feasibility are not accurate, then the conclusion concerning feasibility cannot be accurate. If one is ultraconservative in establishing standards, one reaches an inaccurate result just as surely as being ultraliberal would result in inaccuracy. If use of an inadequate, obsolete, or ultraconservative standard or criteria results in a determination of lack of feasibility when in fact the construction of a project would confer benefits far greater than its costs, then both the Nation and the local area affected are losers.

If I might digress from my prepared speech one moment for the record, sir. At the risk of the censure of the committee of the people present and of my own organization I would like to comment just very briefly on an area that has just merely been touched, namely, the policies of Federal reservations of water with which we have found ourselves faced in the West, simply to make this comment to the committee for its consideration either as a committee or as individual Senators, that perhaps in seeking a bill of the type of the Barrett bill we are headed down the wrong path. It is a good path. We all support it strongly here. But I give for the consideration of the committee the possibility of eliminating the Department of Justice consti-

tutional objection to such a bill by a change to the type of a bill which we might refer to as a quitclaim bill such as was used with the tidelands oil.

Certainly there can be no question concerning the power of the Congress of the United States to dispose of the property of the United States. Perhaps we are going the wrong way. Perhaps we are going the right way. I merely offer that for the consideration of the committee.

I thank you again for the opportunity to appear before this committee, and I am hopeful that I have presented a suggestion which you may feel is a matter for serious consideration.

I wish to assure the committee that if the Colorado Water Congress, or its staff, can be of any assistance to the committee in its work, feel free to call upon us and we will attempt to aid in any way possible.

Senator CARROLL. Just very briefly, if you will, Mr. Shivers.

What is the Colorado Water Congress and how many members do you have? Where does it come from and where does it convene, just briefly, for the record.

Mr. SHIVERS. The Colorado Water Congress was created some 1½ years ago by a group of 19 individuals within the State of Colorado with the assistance of Governor McNichols representing the head of his political body and W. W. Dunbar, the attorney general for the State of Colorado representing the head of his political party.

The CHAIRMAN. Are they different?

Mr. SHIVERS. Slightly. For the purpose of bringing together the water users of the State of Colorado on a grassroots level to determine areas of agreement, not to determine areas of disagreement and to prevent nationwide a unified front on matters in which the State of Colorado stood firmly and solidly as one unit.

Senator CARROLL. Coming from all parts?

Mr. SHIVERS. All parts of the State of Colorado, representatives from every water district within the State, all of the conservancy districts and a good many of the individual irrigation ditches.

Senator CARROLL. I thank you, Mr. Shivers.

Mr. Chairman, any questions?

Senator Martin?

Senator CARROLL. Now we are coming along in fine shape. We only have a few minutes left. I would like to make this suggestion. If anyone in the audience wants to make a 1-minute presentation, if there are not too many of you, please come forward. We do not want to shut anybody off.

I am instructed to say this by the chairman. As you know we have gone through the lunch hour so there could be a continuous presentation.

Now, if there is anyone here who wants to make a 1-minute statement, hold up your hand.

There seems to be no one.

The CHAIRMAN. It doesn't mean there is no one here that doesn't want to make a statement. It could be no one here wants to limit themselves to 1 minute. If there are five who want 1 minute each, fine, or one that wants 5 minutes, fine.

Senator CARROLL. We have Mr. Ben Falsgraff, who raised his hand. Would you come forward?

Mr. Falsgraff has been interested in Colorado water for 50 years. He is a farmer from northern Colorado. He knows local ditch boards, ditch companies, and he has been a great leader in the sugar-beet business.

Ben, you say what you want to say.

STATEMENT OF BEN FALSGRAFF, FARMER, NORTHERN COLORADO

Mr. FALSGRAFF. Mr. Chairman, members of the committee, I attended a great many of the hearings of this nature and this, like many others, is overloaded with a great deal of talent of experts and a few country boys like myself who live on the farm.

I am not a retired farmer but just a tired farmer. It has been my privilege, however, to make a considerable study of this thing and I want to be very particular in saying that I have not made an exhaustive study. There is no such thing as an exhaustive study. I would like to emphasize one thing that Governor McNichols said along the line of lack of information. He sort of brought that out. Many of our troubles come from the lack of information.

Now, as I see it, our greatest hazard or jeopardy or threat in this water situation comes from the decisions of our Federal courts.

At this time I would like to—I have the permission of Mr. Sparks, Judge Sparks, or Director Sparks, to make a little correction in his statement.

In his statement he said that our water resources in Colorado have been depleted by interstate compacts and Supreme Court decisions. In the main that statement is correct. However, that word "Supreme Court," that word "Supreme" should be deleted and put in the "Federal court decisions" and Mr. Sparks has given me the permission to offer the suggestion of that amendment.

What I want to say to this committee is this: That these Federal court decisions—and we all here in Colorado realize what I am talking about—have been so odious on this subject that none of us knows where we are.

Now, recently in your State, Senator Kerr, your capital city has spent something like $385 million, that may not be the correct figure, in perfecting a water program. Neither you nor the other members of this committee and myself or anyone in this audience knows at what minute some Federal judge may come along and rule that that water that your people have impounded down there belongs down the river somewhere, and through the philosophy of the tributary stream philosophy it belongs down the river there and should go down there and if you allow me to be ridiculous for the purpose of floating your muskrat out of his grass hut. That sounds ridiculous, but some of these Federal court decisions are more ridiculous than that yet.

Now, the wildlife folks and the wilderness folks are more concerned over the welfare of a little muskrat down the river, apparently, to me, than they are in the welfare for, say, 50,000 little children in your capital city of Oklahoma. That is the way that thing rings to me like. That is one thing I want to impress on you folks, the main hazard that we face here in this State is that these Federal decisions, unfortunately, these Federal decisions—now, don't get the notion that I am ridiculing the court. There is no person in all this wide land,

I don't believe, that has more respect for the courts than I have and the judges thereon, but we make mistakes. Every time a judge dissents somebody is in error. So we all make mistakes. None of us are infallible.

Now, that is about all I care to say. The greatest hazards in all this thing are the Federal court decisions and I think you gentlemen realize the thing. They are encroaching on matters that belong to the States and recently the Congress of the United States with the approval of the President took care of the tidelands oil. You can take care of this water situation and this Government of the United States when it goes out into the State should abide by the rules laid down by the States.

If you folks have any embarrassing questions, I will be glad regardless of how embarrassing they may be.

Senator CARROLL. Thank you very much. You made a very forceful and clear statement.

Mr. FALSGRAFF. Thank you.

Senator CARROLL. Any questions, Mr. Chairman?

Senator Martin?

Thank you very much for your presentation.

Mr. Chairman, is there a Mr. Macht here?

Mr. Chairman, I ask that his statement, which is a short statement, this comes from the Colorado Wildlife Federation, be offered at this point in the record.

The CHAIRMAN. Fine.

Senator CARROLL. It is a short statement.

(The statement appears in the Albuquerque hearing.)

Senator CARROLL. Mr. Chairman, there is another statement here from George W. Colburn, executive secretary of the Ground Water Commission of the State of Colorado.

It is a 1-page statement, four short paragraphs, which I think might be helpful to get in the record.

The CHAIRMAN. Very good.

(The statement follows:)

STATEMENT OF STATE OF COLORADO GROUND WATER COMMISSION PRESENTED BY GEORGE W. COLBURN, EXECUTIVE SECRETARY

1. Increased activity and acceleration of ground water projects by U.S. Geological Survey-State cooperative programs.
2. Passage of legislation outlining and confirming the supremacy of State water laws and indicating that conformation thereto, must be made by Federal agencies.
3. The acceleration of release of data and findings of fact by Federal agencies so that those data contained therein, do not become obsolete before release.
4. The release of findings by Federal agencies of data where such data would tend to place responsibility upon an agency for negligent or adverse activity to the detriment of public health or welfare.

Senator CARROLL. We also have a statement, Mr. Chairman from the Bureau of Reclamation that has to do with water losses and sediment. It is a 13- or 14-page statement. It can go in or be made part of the file.

The CHAIRMAN. Let it be made part of the record.

(The statement follows:)

Statement by K. B. Schroeder, Bureau of Reclamation, Denver, Colo., on Water Losses and Sediment, State of Colorado

WATER LOSSES

There are certain water losses associated with water resource project development that do not contribute directly to the prime purpose of a project. These losses in general are associated with storage of water, conveyance of water in river channels and canals, and in the application of water to irrigated areas. These items will be taken up separately.

Storage

When water is impounded in reservoirs for the purpose of storing or holding it for use as needed, certain losses are experienced. The prime loss is that associated with evaporation from the reservoir water surface. Evaporation from the reservoir surface may not be a total new loss considering the use in the area before the reservoir was constructed. However, the evaporation after construction is an identifiable existing loss. Another loss associated with reservoir impoundment is produced by the vegetative growth that develops around the periphery of the reservoir. This loss may be particularly high in the delta areas of reservoirs. As sediment deposits in reservoirs, it may build a fan or delta at the head of the reservoir or wherever stream flow is entering the reservoir area. Willows, cottonwoods, and tamarisk (salt cedar) are particularly adaptable to growth in these areas. This phreatophytic vegetation is most prevalent in lower elevations and warmer climates. It consumes large amounts of water during the warm weather period when the depth to groundwater is small. Another loss associated with storage is that of seepage around the dam. Not all seepage can be considered as a loss. Seepage that can be collected in drains and conveyed immediately back to the river channel below the dam will be available for downstream use. The net loss is usually attributed to seepage accruing to new areas within the flood plain that previously did not support vegetation or have evaporation from swamp or ponded areas.

River valley conveyance

Water is always lost in river valleys and from the river channel. Some is inevitable and has been experienced throughout the life of the valley. There is evaporation directly from the stream water surface, from the channel edge, from wetted soils and sand bars. Streams having wide braided channels and shallow depths present a larger exposure for evaporation than narrow, deep, and fast-flowing streams.

Vegetative growth usually adjacent to the stream is another source of loss. A stream channel may be associated with the valley developed in geologic time; some are narrow and deep, others are wide and flat. Flood flows conveyed by a river in narrow deep valleys experience less loss than streams in wide flat valleys wherein floods inundate a considerable extent of the valley. Large vegetative growth areas in the wide flat valleys may be irrigated during flood periods. Such streams normally experience considerable amount of loss. In certain cases, streams with wide valleys and shallow main channels will maintain a high water table beneath the adjacent flood plain and valley area. Vegetative growth in the flood plain is continually subirrigated by water from the stream or by groundwater from the higher adjacent areas. Again certain types of phreatophytic growth, such as cottonwood, willows, and tamarisk will consume a large amount of water in valleys of this type.

In a few instances the water table below streambeds may be at considerable depth. This is particularly true of streams that do not have perennial flow. A port of the water conveyed during flood flow periods would be lost from the streambed to the lower groundwater table. This is not necessarily a net loss as this water accruing to the deeper groundwater basin will be available at some other point either farther down the valley or some adjacent valley.

Conveyance in canals and artificial channels

Irrigation of any area requires the conveyance and distribution of water to the farm lands. This is done primarily through a system of canals and laterals. In the operation of these systems, there are operational wastes incident to furnishing each farmer a supply of water as required. These wastes are normally termed "operational wastes" and are caused by the operators not being able to predict accurately the losses through seepage and evaporation that may be experienced from the canal. The wastes are usually discharged in specially

prepared wasteways that are conveyed by other artificial channels or natural channels back to main river channels. Operational wastes are not a net loss but are available as they reach the main channel for use downstream. However, it is inevitable that some of the waste flows will be lost in conveyance to the main channel. This takes place as evaporation loss from the water surface area of the canal and as evaporation and transpiration loss due to vegetative growth immediately adjacent to the canal. These losses cannot be retrieved. Canals constructed through the irrigated areas are usually higher than the groundwater table in the area. Seepage is always experienced from the canal in varying amounts. Seepage in sandy soils is, of course, higher than seepage in the tighter clay soils. Seepage losses from canals will either continue vertically to the groundwater table and be recoverable through pumping or move to natural channels and be available for downstream use. In certain instances these losses are moved laterally and support additional growth in swamp or waterlogged areas, in which case the loss is irretrievable.

Irrigated areas

Water used consumptively is that water used on the farm area through transpiration by crops or by direct evaporation from the soil surface. This consumptive-use water is supplied from precipitation and the application of irrigation. Irrigation water is not always uniformly applied and is often applied in amounts greater than the soil profile can store within the root zone of the crops. When the root zone area is supersaturated, either through irrigation or precipitation, the excess water percolates vertically to the water table beneath the land.

Water thus reaching a shallow water table will move laterally to some natural channel or break out in surrounding low areas. There are certain losses from the movement of this water as it wets natural channel areas that were previously ephemeral. Thus the water supports additional vegetation and there are also losses of water through evaporation from the wetted surface and directly from the water surface. Water is also lost as it breaks out into the low lands, the common term for it is "new seeped areas." If the water does not move readily in the underlying aquifier, the water table will rise, requiring drains to move the water artifically out of the irrigated area from which there is loss experienced as in any natural channel.

The Bureau of Reclamation has constructed 17 reservoirs in Colorado and 1 is presently under construction. The 18 reservoirs will impound about 1,500,000 acre-feet of water. The surface area of these reservoirs aggregate at full capacity about 28,000 acres. Table 1 lists these reservoirs, the project, location, capacity, water surface area, elevation, and provision for sedimentation. Of the 18 reservoirs, one is above 10,000 feet in elevation, one is between 9,000 and 10,000 feet, four are between 8,000 and 9,000, five are between 7,000 and 8,000 feet, six are between 5,000 and 7,000, and one is below 5,000 feet. The evaporation at full capacity may be about 85,000 acre-feet annually. Losses for average operation are about 65,000 acre-feet annually. All of the Bureau reservoirs, with the exception of one, that have been constructed in Colorado are in the mountain areas. These reservoirs do not receive large amounts of sediment and do not have delta areas from which large losses may be expected. Evaporation in the mountain areas is relatively small. We are not experiencing large amounts of vegetative growth around the periphery of these reservoirs. Our one reservoir at lower elevation is Bonny Reservoir on the Republican River near the Colorado-Kansas line. This reservoir has 5,000 acres of surface area at full capacity from which approximately 45 inches of water loss may be anticipated annually. The sediment inflow to this reservoir is estimated at 360 acre-feet annually. It is expected that the sediment will form a delta area and vegetative growth will establish itself on the delta and around the periphery of the reservoir. This is a problem that we recognize will have to be combated as it develops.

The Bureau of Reclamation is presently supplying, either supplementally or in total, irrigation water to approximately 880,000 acres in Colorado through eight projects. The Bureau has approximately 1,500 miles of canals and laterals in operation in the State. We have constructed approximately 400 miles of open drains on these projects.

The net water loss from irrigated areas is not as great as shown in project reports of canal seepage, canal waste, and excess water applied to irrigated lands. Much of the water so reported is excess to project needs, returns to

natural channels and is available for downstream uses or is pumped from the underlying aquifer.

A good example is the experience of the South Platte Basin. The South Platte Basin inflow as measured from all tributary streams emerging from the mountains is approximately 1,045,000 acre-feet annually. Present imports to the basin from other basins is approximately 430,000 acre-feet. The total available water to the basin is about 1.575,000 acre-feet. The average flow at the State line at Julesburg, Colo., is about 283,000 acre-feet. The net water available for use is about 1,292,000 acre-feet. In 1949, reported irrigated acreage in the basin was about 912,000 acres. Average use per irrigated acre within the basin is about 1.4 feet. The average consumptive use of the croplands within this area is estimated to be about 2.2 feet. Average precipitation is about 1.1 feet. The net requirement for irrigation then is about 1.1 feet. The resulting overall efficiency of water use on the irrigated lands of the entire basin is approximately 75 percent. There is lost within the Platte Basin about 290,000 acre-feet. This loss is distributed in the many reservoirs in the area, channel losses, seeped areas, etc. The amount recoverable of the 290,000 acre-feet of loss is necessarily associated with economic incentive. Better application by the farmers, more precise operation of the irrigation districts, consolidation of the innumerable reservoirs, lining of canals, restriction of phreatophytic growth, additional drainage, and better maintenance of drains are all factors in water saving.

The incentives to accomplish water savings are associated with economics and present structure of water-right laws. It is easier to operate an irrigation system and to irrigate land when water is plentiful. Diligent system operation requires additional labor and innumerable accurate measuring devices. If an irrigation district has the right to plentiful water for which there is no additional charge at the source, there is no incentive for saving. This is also true of the farmer because diligent operation requires added investment in land development and labor in application. Farmers whose rights are limited and have a limited water supply are more careful in their application. Districts with a limited water supply will waste less water and prevent canal conveyance losses by lining. The prime requisite of our irrigation projects is to supply water to the farmers. Our project maintenance funds are supplied by the water users whose prime objective is receiving adequate irrigation water. The inventory of all flows and losses on the systems requires an elaborate measuring system and considerable expenditure. Our project water users are not willing to defray these expenses. Inventory of all wastes and losses on the project would necessarily have to come out of research-type appropriations. These funds have not been made available in sufficient quantities to inventory properly the losses on our projects. Hence, we are unable to give you detailed reports on the water losses experienced on our project areas.

In the Bureau of Reclamation, we recognize that in many basins the only additional water supply available for development of new lands must come from the salvage of losses. We also recognize the advance of phreatophytic vegetation into many of the basins which must be suppressed to preserve the existing supplies. In Colorado, we do not have large infestations of phreatophytic growth in any of the river basins. There is some indication of a potential salt cedar infestation in the lower Arkansas Basin and the advance of phreatophytic growth into the upper Rio Grande Basin. There is presently scheduled an investigation of the possibility of salvage in the Rio Grande Basin.

We are presently preparing a report in cooperation with the State of Colorado, "The Potential Salvage in the Closed Basin of the San Luis Valley." It is anticipated that this report will demonstrate the feasibility for salvage of approximately 100,000 acre-feet of water in this basin. The salvage is possible. However, the use of the water and the repayment of the engineering works have not been determined. The closed basin salvage is from an area of approximately 133,000 acres. Our plan is to lower the ground-water table in the area by pumping through a conveyance channel leading from the area. The lowered ground-water table will retard evaporation and use by nonbeneficial vegetation.

We have also, through our research activities, conducted a series of studies on the possibility of applying a thin protective film on reservoir surface areas to retard evaporation. Our experiments to date show that from a practical viewpoint, we may be able to achieve some success in this field. (See p. 43 of Lake Hefner report which indicates a 35-percent saving is possible.) The results of

these studies are contained in a report entitled "Water-Loss Investigations: Lake Hefner 1958 Evaporation Reduction Investigations."

We are also conducting research in the field of canal lining. Our aim is to achieve an effective low-cost lining.

Sedimentation

The natural processes or laws of sedimentation rarely benefit a water resource project development; hence, the effect of sedimentation is a problem that must be forecast and the costs for handling added to the overall project. The problems encountered are reservoir deposition, deposition in canals, and the effect upon natural channel regime.

Reservoir Deposition

Sediment carried into reservoirs by the inflowing streams deposit in the reservoir pools and deplete space available for storage. Experience has shown this deposition does not conveniently fill a dead storage pool in the lower part of the reservoir but deposits throughout the reservoir and depletes the upper usable space. In certain instances large sediment deposits will occur at the head of the reservoirs, creating delta areas.

The policy within the Bureau is to provide extra storage in reservoirs for sediment deposition. Generally, 100 years of deposition is provided before encroachment upon the space required for project storage. This is a matter of economics and each reservoir is studied individually for the proper balance. Consideration is given to possible replacement, value of the damsite, and use of the space during the depletion period.

The problem is forecasting the deposition rate and distribution of sediment within the reservoir. Sediment sampling is the basis for forecasting most yield rates. Methods of forecasting yield rates and distribution within reservoirs have been developed by the Bureau which are empirical and based upon past experience. A limited amount of research money is being spent cooperatively with other Federal agencies to perfect these procedures.

A particular problem being studied at present is the formation of reservoir deltas. When large deltas form at the head of reservoirs, they damage existing facilities above the reservoir level and provide an area for phreatophytic vegetation and resulting water loss. If we can forecast delta formation, additional right-of-way will be purchased and maintenance provided to combat the potential water losses.

Deposition in canals

Direct diversion of streamflow to irrigation distribution systems will divert both water and sediment. Canal systems as a rule have much flatter slopes than streams; hence, the sediment deposits in canal, and cleaning is then required to maintain capacity. When sediment load is forecast, designs are altered to handle the sediment. General policy in the Bureau is to prevent large amounts of sediment from entering the canal system. This is done by specially designed excluders at the diversion headworks or use of settling basins at the head of the canal. Sediments deposited in the settling basins are removed by dragline or dredge.

Stream regimen

The problems of stream regimen are now becoming apparent. The problems arise from stream channel degradation and aggradation. Use of clear water from the mountain areas for irrigation or other purposes means this water is no longer available to transport sediments yielding from the desert areas in the lower basins. In addition, there are strong indications that modern land use of the plains and desert areas have increased the sediment yields from these areas. The resulting stream channel aggradation raises valley water tables and increases water losses from the valley. Channel control is presently being investigated by the Bureau in several areas, although not in Colorado.

As explained previously, there are irrigation losses and wastes associated with delivery of water to irrigated lands. When an irrigated area is at a much higher elevation than the main valley channel, a problem is encountered in returning these to the lower valley. The natural channels draining the high areas were in a relatively stable regime, but irrigation wastes combined with the natural storm flows will, in many cases, erode these channels. We have found that artificial control of these channels is necessary and must be included as a project cost. In some cases it has been necessary to do this type of work on

old operating projects because it was overlooked in the initial plan. Some of this type of work is now being done in the Grand Valley area in Colorado.

Bureau developments in Colorado

The existing reservoirs built by the Bureau in Colorado have not presented difficult sedimentation problems. The attached table shows the annual sedimentation rates for reservoirs in Colorado, and it may be noted most of these are small. These low rates are because most of the reservoirs have been constructed in the mountainous areas.

Our study of sedimentation rates in Colorado show that, in general, sediment yields in the high mountain areas will be less than 0.10 acre-foot per square mile. The plains and desert area rates are much higher. For example, the rate forecast for Bonny Reservoir is 360 acre-feet per year, which is 0.22 acre-foot per square mile of drainage area. We forecast the sediment rate for the potential Narrows Reservoir on the South Platte near Fort Morgan as 1,500 acre-feet per year. Most of this sediment will come from the plains portion of the drainage area as represented by stream basins, such as Kiowa and Bijou Creeks.

On the Colorado River storage project, Glen Canyon Reservoir forecast is approximately 100,000 acre-feet of sediment deposition annually. Provision has been made to store these sediments for approximately 200 years before appreciable encroachment upon usable storage. Most of the sediment that will deposit in Glen Canyon comes from the desert areas of western Colorado, northwestern New Mexico, and southeastern Utah. Unit yields from this area average greater than 0.65 acre-foot per square mile annually. The yield from the lower San Juan Basin is about 1.40 acre-feet per square mile annually. An annual sediment deposition of 3,300 acre-feet has been provided for in Navajo Reservoir. We anticipate Flaming Gorge Reservoir storage depletion will be approximately 2,000 acre-feet annually.

Bureau direct diversion projects in Colorado have experienced only minor sedimentation problems that are being taken care of by annual water user maintenance. However, studies on the Uncompahgre project are being made to eliminate as much as possible even these minor costs.

The Bureau has not been called upon to study stream basin aggradation problems in Colorado. If such problems are impending, they have not as yet reached proportions that are of concern to water user organizations that would be affected.

Bureau reservoirs in Colorado

Reservoir	Project	Capacity acre-feet	Reservoir surface area acres	Elevation in feet sea level	Annual sediment rate acre-feet	River
Carter Lake Reservoir	Colorado-Big Thompson	112,230	1,144	5,759	4.5	South Platte Basin.
Flatiron Reservoir	do	760	47	5,473	2.6	Do.
Lake Estes	do	3,070	185	7,475	15.5	Big Thompson.
Granby Reservoir	do	539,800	7,260	8,280	.6	Colorado.
Horse Tooth Reservoir	do	151,800	1,900	5,430	22.0	Off channel.
Marys Lake Reservoir	do	930	42	8,040	(1)	Tributary Big Thompson.
Shadow Mountain Reservoir	do	18,400	1,850	8,367	9.5	Colorado River.
Green Mountain Reservoir	do	154,600	2,130	7,950	60.0	Blue River.
Willow Creek Reservoir	do	10,600	303	8,130	12.7	Willow Creek.
Rattlesnake Reservoir	do	2,180	97	6,580	(1)	South Platte Basin.
Bonny Reservoir	Missouri River Basin	170,200	5,040	3,710	360.0	Republican.
Fruitgrowers Reservoir	Fruitgrowers	4,600	476	5,485	19.0	Alfalfa Run.
Jackson Gulch	Mancos	10,000	220	7,825	(1)	Off channel, Mancos Reservoir.
Paonia Reservoir [2]	Paonia	21,200	325	6,448	100.0	Muddy Creek.
Vallecito	Pine River	129,700	2,720	7,665	(1)	Pine River.
Platoro	San Luis Valley	60,000	947	10,034	8.0	Conejos.
Taylor Park	Uncompahgre	106,000	2,040	9,330	(1)	Taylor.
Vega	Collbran	33,800	960	7,984	12.2	Plateau Creek.
Total		1,529,870	27,686			

[1] Negligible.
[2] Under construction.

Senator CARROLL. Are there any other matters to come from our witnesses here before the chairman? Does anyone else desire to be heard?

Are there any other Federal agencies desiring to submit reports at this time for the record?

Mr. Chairman, I think I ought to say, speaking in behalf of the Congressman from the Fourth Congressional District, who is chairman of that most important and powerful House Committee on Interior and Insular Affairs, Congressman Aspinall, he would liked to have been here today. He has a great interest in this subject not only as a leader in Colorado but a national leader in this field. He expresses his regret that he could not be here as did Congressman Rogers of Denver. Byron Rogers has asked me to express his interest in this matter. He will be studying the record of this hearing closely. I observed here earlier the administrative assistant to Congressman Byron Johnson. Is Jim Thornton in the room?

Byron Johnson is the Congressman from the Second Congressional District who has done such a yeoman job on the question of water contamination and pollution; has been following this subject more than a year. He has been in close communication with Governor McNichols and with other congressional offices, including my own. I am sorry that Byron Johnson could not be here, but he is busy in Washington on other matters.

Are there any other witnesses now to appear here in behalf of any group in the State of Colorado?

Let me conclude by saying that we express our heartfelt thanks to you, Mr. Chairman and to Senator Martin and your excellent staff for coming to Colorado so that we could make this full presentation, on behalf of the people of Colorado, of our water development problems, our need for conservation, our need for proper utilization. Of course my senior colleague and I stand ready to help this Senate committee in its very important work.

Again let me thank you on behalf of the Governor and the entire congressional delegation and the people of Colorado for taking your time to come in here to hear our story and give us the benefit of your experience and advice. We hope we will merit your solicitude on the problems presented today and those which might arise in the future.

The CHAIRMAN. Thank you, Senator Carroll, for myself and my colleagues on the committee and our staff. We want to express our appreciation for the widespread response that has been given here today and every facet of it; the sum total of the expressions of the will of our people in the States will constitute the mobilized power that will result in more aggressive and more intelligent and more comprehensive action by the Federal Government.

This is one of the best hearings we have had. Our good friend there from, I believe, northeastern Colorado, indicated he thought it was loaded with certain classes of testimony. I want to say to him that as we have gone about in the many States thus far heard, many in the West, that in some areas we have had a preponderance of statements representing one viewpoint and then in the next State we would have a preponderance of statements representing other viewpoints.

I am of the opinion that before we are finished we will have received a very comprehensive statement of viewpoints and opinions with reference to all of the different attitudes and interests and that the record will be averaged out and leveled out.

We have had some things here today that we have not had before, principally, I would say it was the statement by Mr. Roberts, or is it Dr. Roberts?

Senator CARROLL. Dr. Roberts.

The CHAIRMAN. Well, you know in Oklahoma mighty few experts ever get to be doctors and not all doctors get to be experts. But I thought he gave us a very interesting and a very challenging statement. He referred to something that has been much in the mind of the chairman of this committee, and that is the absolute necessity that this Nation not be caught short in the matter of research and the development of knowledge with reference to the possibility and the means of controlling weather, as we have been and now are in the matter of the development of missiles and satellites. It would be in my judgment a mistake of unknown magnitude if our country were to permit any other nation in the world to arrive, if it is possible to arrive at the point of being able to not only forecast but control the weather, prior to the time that we would be equally qualified in that field of natural resource control.

We are glad to be here. I hope we may have the opportunity to come again.

Do you have any remarks, Senator Martin?

Senator MARTIN. It has been a very good hearing. I am especially pleased to be with you here today.

Senator CARROLL. I would like to make one short observation. Where I use the word "I" I ask unanimous consent to change it to "we" and have my senior colleague, Senator Allott included. This is what I had in mind when I used the word "I." He joined in inviting this committee in here and I want to see that he gets full consideration for your being here today.

The CHAIRMAN. If there are no further remarks the committee will adjourn.

(Whereupon, at 2:45 p.m., the committee adjourned.)

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